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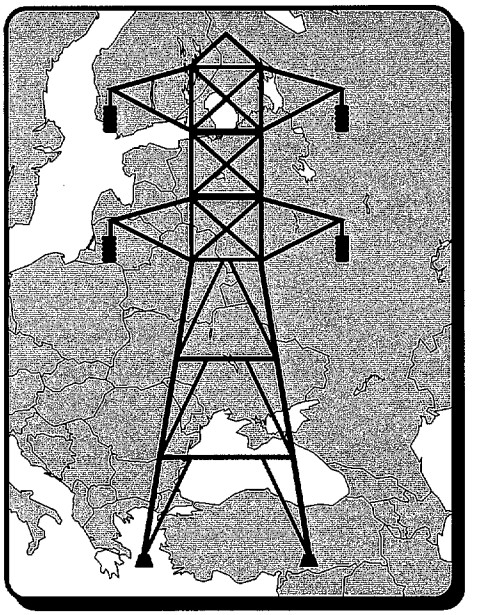
# Central and Eastern Europe Regional Energy Efficiency Project EUR-0030-C-00-2053-00



## Energy Pricing, Energy Efficiency, and Energy Sector Restructuring Component

Final Report
December 1996

**Volume IX**

Prepared for:
U.S. Agency for International Development
Bureau for Europe and NIS
Office of Environment, Energy, and Urban Development
Energy and Infrastructure Division

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# CENTRAL AND EASTERN EUROPE
# REGIONAL ENERGY EFFICIENCY PROJECT
# EUR-0030-C-00-2053-00

**Energy Pricing, Energy Efficiency, and**
**Energy Sector Restructuring Component**

**Poland**
**World Bank Support**

*Task Completion Memorandum*

*Prepared for:*

U.S. Agency for International Development
Bureau for Europe and NIS
Office of Environment, Energy,
and Urban Development
Energy and Infrastructure Division

*Prepared by:*

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October 1995

# CENTRAL AND EASTERN EUROPE
# REGIONAL ENERGY EFFICIENCY PROJECT

*Task Completion Memorandum*

## *Poland - World Bank Support*

**Summary Task Description**

Hagler Bailly participated in a one-week World Bank (WB) Mission to the Upper Silesia Power Distribution Company (GZE). The purpose was to evaluate a demand-side management (DSM) component of the WB distribution system loan which would support the implementation of DSM pilot demonstration project.

**Specific Goals and Objectives**

The objectives of the mission was to establish the framework and scope of work for such a demonstration pilot program.

**Expected Outputs**

The mission is expected to define a potential DSM pilot demonstration project as a part of the distribution system loan project of the WB.

**Deliverables**

Trip report and draft terms of reference (TOR).

**Results and Next Steps**

Hagler Bailly produced a trip report, draft terms of reference, and contributed to the WB aide-memoire, which included DSM as a recommended project component.

It is recommended that USAID and the WB collaborate on future power sector loans that could include DSM as a component.

# MEMORANDUM

**To:** Robert Archer, USAID

**FROM:** David Wolcott

**DATE:** April 14, 1995

**SUBJECT:** Trip Report (World Bank Poland DSM Loan)

This memorandum is a report of my trip to Poland from March 31 to April 8, 1995, to participate in a World Bank mission, under contract to USAID. This was an identification mission for a proposed loan to the Upper Silesia Power Distribution Company (GZE) for distribution system modernization and demand-side management (DSM) investments. My role was to provide input relevant to the DSM component of the loan. An Aide-Memoire was written and left with GZE.

On Saturday, April 1, on my way through Warsaw, I had a dinner meeting with Mr. Mirek Duda and Mr. Marek Grzybowski of the Energy Restructuring Group (ERG).

I joined the World Bank team in Gliwice, Poland on Sunday, April 2. The mission, led by Mr. Dale Gray and including five other World Bank staff and consultants, had gotten underway during the preceding week.

On Monday, April 3, I joined the entire team for a meeting with Mr. Piotr Kolloch and Mr. Waldemar Osinski, president and vice president, respectively, of Infoenerg, a subsidiary of GZE tasked with developing a Management Information System (MIS) for the company.

For the remainder of the day, Mr. Gray and I met with Mr. Piotr Rafalski, head of the Design and Development Department, and his staff, Mr. Manfred Wawrzynosek and Mr. Zbigniew Lewandowski, who are currently responsible for DSM at GZE.

On Tuesday, April 4, I joined the entire team for a meeting with Mr. Wojciech Golebiowski and staff of GZE's Investment Planning Department.

On Wednesday, April 5, I had a meeting with Mr. Krzysztof Gdula, chief of the Customer Service Department, and his staff.

On Thursday, April 6, I had a breakfast meeting with Mr. Gray and Mr. Arturo Roa, a World Bank senior procurement specialist who will be working on the DSM component of the loan. We discussed again what my contribution to the mission would be and our strategy for a meeting later in the day on DSM with Mr. Piotr Kukurba, GZE's president.

Most of the team then had a meeting with Mr. Leszek Torc, chief of the Marketing Department. The entire team then had a final meeting with Mr. Kukurba at which Mr. Gray presented the Aide-Memoire and described the entire World Bank loan program. I gave a brief summary of the DSM component in this context.

After the main meeting with the whole team, we continued a separate meeting with Mr. Kukurba specifically on the DSM component of the loan. Mr. Roa joined me as did Mr. Jan Jicha, a World Bank consultant from the Czech Republic who will be involved in field implementation of the loan activities. Mr. Kukurba was joined by Messrs. Gdula, Rafalski, and Wawrzynosek. I traveled to Warsaw that evening and had two meetings on Friday, April 7. The first was with Mr. Jaroslaw Dybowski, deputy director of the Electricity Trading Department at PSE, responsible for developing the long-term contracts with generators that resulted from PSE's supply-side bid solicitation earlier this year. His department is also responsible for the development of the BST and all other transfer (wholesale) tariffs, including the proposed DSM resource payments.

My second meeting in Warsaw was with Ms. Maryla Jakubowicz, energy program officer at the USAID mission. I gave her a full briefing of my activities and the results of the World Bank mission. With that meeting, my participation on the mission was completed.



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**DRAFT**

**POLAND**

**UPPER SILESIA POWER DISTRIBUTION COMPANY**

**WORLD BANK DISTRIBUTION SYSTEM LOAN**

**DEMAND-SIDE MANAGEMENT PILOT PROJECT**

TERMS OF REFERENCE

## Summary

The demand-side management (DSM) component of the proposed World Bank distribution system loan to the Upper Silesia Power Distribution Company (GZE) in Poland has the goal of supporting the implementation of a practical DSM pilot demonstration project. This activity will build upon the DSM pilot project previously designed with support from the U.S. Agency for International Development (USAID). In the process, significant capabilities will be developed within GZE and its subsidiary companies to implement DSM as both a load management and energy efficiency resource and to market DSM as a customer service. The World Bank support is expected to be US$ 5-15 million of foreign exchange credits, which will provide partial financing of the DSM pilot project activities.

## Background

Starting in 1992, USAID sponsored a technical cooperation project in Poland focusing on electric utility DSM and integrated resource planning (IRP). DSM refers to utility efforts to modify the amount and timing of customer demand and consumption of electricity. IRP refers to a systematic utility planning process to identify and acquire all cost-effective electric resources (supply-side and demand-side) required to meet current and future energy and capacity needs. The project was conducted within the context of the restructuring and reform of the Polish energy sector toward

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more market-oriented operations, a process which was coordinated by the World Bank and included the participation of USAID and other multilateral and bilateral donors.

The USAID DSM/IRP Project supported work with two Polish utility counterpart organizations, the Polish Power Grid Company (PSE) and GZE, to accomplish the following tasks:

- **Institutional Policy Development.** Through a number of executive management seminars and policy papers, DSM and IRP concepts were communicated to high level officials in Poland's government and energy sector. As a result, provisions were included in the current draft Energy Law (November 1994 version, amended February 1995) for energy enterprises to conduct IRP (Article 19) and for energy enterprises to recover DSM costs in tariffs (Article 49). Also, PSE agreed to acquire DSM resources that provide system-wide benefits, through a competitive process that compares DSM to the cost of generation.

- **National Assessment of DSM Potential.** A rigorous, quantitative analysis of the economic and achievable DSM potential was completed in December 1993, focusing on resources that could be realistically implemented over a six year period. The analysis was specifically oriented to the loan appraisal process of the World Bank, and was accomplished with DSManager, a DSM economic analysis software model, for which a license and training were provided to PSE. The result indicated a DSM potential of 1,738 GWh of energy savings per year (equivalent to 8 percent of projected incremental energy requirements) and 552 MW of demand savings (equivalent to 17 percent of projected incremental demand requirements), which would displace all of the new generation called for in PSE's Least-Cost Supply Plan over the same six year period.

- **Establishment of IRP Unit at PSE.** In the first tranche of World Bank lending for PSE's transmission system, a loan condition required PSE to complete an IRP Action Plan by June 1994 and establish an IRP unit within the company by December 1994. These activities were accomplished, which included the provision of a software license and training for the Integrated Planning Model, a state-of-the-art utility IRP



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tool. PSE senior management also received executive training, including an extensive IRP study tour in the U.S. One of the results was PSE's competitive solicitation of supply-side bids from generators in November 1994, which established a market-determined avoided generation cost of US$ 0.036/kWh. This bidding process and results framed the next step that PSE anticipates taking in 1995 which is to solicit comparable competitive bids for DSM resources.

- **Design of a DSM Pilot Project at GZE.** A detailed design of a DSM pilot project to be implemented at GZE was completed in December 1993, focusing on the industrial sector. To support the pilot project design, market research activities were undertaken, such as interviewing GZE's customers through focus groups. End-use load research equipment and training were provided to GZE technical staff, who gathered extensive end-use consumption data from its customers. The pilot project was designed to reach 30 of GZE's industrial customers over an 18 month period at a cost of US$8.3 million. Throughout 1994, USAID continued to support GZE's efforts to identify: 1) candidate customers for participation in the pilot, 2) energy service companies (ESCOs) that could be involved in project implementation, 3) sources of capital financing, and 4) sources of utility incentives e.g., DSM resource payments from PSE.

Referring to the last activity, Pilot Project Design, GZE requested assistance from the World Bank for distribution system investment credits, including the resources necessary to implement the DSM pilot project. In January 1995, the Polish Ministry of Finance agreed to guarantee a World Bank "distribution system and DSM" loan for GZE. In a mission to Poland in March and April 1995, the World Bank established agreement with GZE regarding the general framework of the loan, as presented in an Aide-Memoire. Relevant to DSM, meetings were held with GZE's president, with senior staff in the Design and Development, Investment Planning, Customer Services, and Marketing Departments, and with officers of Infoenerg, A GZE subsidiary tasked with developing a Management Information System. Meetings were also held with senior staff of PSE's Electricity Trading Department and with the USAID mission in Warsaw.

Implementation of the pilot project is expected to follow closely the strategy and tactics detailed in the USAID report *Demand-Side Management in Poland: Part 2: Pilot Project Design* (December 1993). The DSM component of the World Bank loan is described in the Aide-Memoire as comprising the following activities:

1) **Phase 1 DSM (immediately)**: GZE will contract with PSE for DSM resource payments to be made for load management and interruptible service to be provided to PSE during system peaks. GZE will engage an ESCO to develop load management projects at large industrial enterprises.

2) **Phase 2 DSM (following passage of the Energy Law)**: GZE will use authorities in the Energy Law to set retail tariffs (subject to regulation) that minimize costs of wholesale rates from PSE (the Bulk Supply Tariff in the near-term; hourly pool prices in the longer term). Since tariffs will allow recovery of DSM costs (including lost margin), GZE can extend Phase 1 DSM activities to include load management and energy efficiency for all customers.

3) **Management Information System (MIS)**: GZE will fully integrate DSM data requirements into the "Informatics" system (customer and geographic information systems) that is currently planned.

4) **Technical Assistance**: The World Bank and USAID will support the above activities with technical assistance to focus on developing GZE staff capabilities to implement DSM programs.

## Objectives

The objectives of the DSM component of the World Bank distribution system loan to GZE are:

- To provide some practical and timely results regarding the actual contribution that DSM can make as a power sector resource in Poland;

- To demonstrate the role that Polish utilities can play to work cooperatively with their customers to develop the DSM resource;

- To identify and test alternative incentive mechanisms through which DSM can be implemented in the context of the restructuring of Poland's power sector;

- To develop innovative procurement methods, through which an ESCO is contracted to provide "turn-key" implementation of the pilot project;

- To develop local Polish ESCO capabilities through training and business development activities; and

- To monitor and evaluate the results of the pilot project to improve its design and to support expansion of the pilot to a full-scale program, if warranted.

Scope of Work

In addressing the objectives described above, the DSM component of the World Bank loan will be implemented through performance of the following Tasks:

**1) Develop Project Terms of Reference (TORs) and Establish Project Implementation Unit (PIU)**

Using USAID technical assistance resources, GZE will develop detailed TORs to implement the DSM component of the World Bank loan. The TORs will be based largely on the USAID Pilot Project Design report, however, they will reflect new information and the current status of GZE in the Polish electricity sector restructuring process. Initially, the TORs will focus on the opportunities available under the Phase 1 DSM activity. GZE will submit the TORs for review and approval by USAID and the World Bank. GZE will also formally establish a "DSM Unit" within its organizational structure as the PIU (e.g., in the Customer Services Department), and will appoint a Project Manager from among its senior staff to lead the DSM Unit.

**2) Identify Candidate Customers for Project Participation**



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GZE will review load data in its possession to identify prospective customers for participation in the pilot project. The first screening of customers will be completed according to the following technical criteria conducive to load management and interruptible service: 1) relatively large demand, e.g., the largest industrial customers, 2) significant peak demand during the total system peak, and 3) variability in the load curve that indicates the potential for load shifting. A secondary screening will focus on the following criteria conducive to sustainable participation in the project: 1) willingness to work cooperatively with GZE, 2) evidence of the ability to survive the economic transition, and 3) motivation to implement DSM load management measures. GZE will conduct site visits of candidate customers to confirm their status as potential project participants.

**3) Contract with an ESCO**

GZE will enter into a contract with a qualified ESCO to implement the pilot project on a "turn-key" basis which means that the ESCO will take complete responsibility for the successful performance of the pilot project. The ESCO will be expected to: 1) conduct engineering analyses of technical opportunities, 2) specify, procure, and install appropriate DSM equipment, 3) operate and maintain the DSM equipment over its useful lifetime, 4) enter into relevant agreements with the participating customers, 5) subcontract with local ESCOs and energy engineers for project implementation, and 6) finance a substantial portion of its activities through its own or third-party resources (e.g., from the ESCO's corporate finances, the participating customers, and other sources of equity and commercial and concessionary debt). When the ESCO is under contract, GZE will provide it with all information and assistance necessary for development of DSM projects at the sites of candidate customers identified in Task 2.

**4) Negotiate Agreement with PSE for DSM Resource Payments**

GZE will meet with relevant PSE officials to reach a "master" agreement regarding PSE's DSM resource payment requirements. While it is clear that specific agreements will have to be concluded for specific blocks of load management and interruptible service, it is anticipated that the general outlines of the business transaction

can be defined up-front. Particular attention will be paid to PSE's requirements for "metering and verification" (M&V) of the DSM resource.

**5) Conduct Site Audits and Engineering Analyses**

The ESCO contracted by GZE will initiate detailed energy audits at the candidate sites and will conduct engineering analyses of DSM measures recommended in the audits. The ESCO will also install and monitor end-use load research equipment to establish a pre-installation baseline of energy consumption data. Based on the engineering analyses, the ESCO will prepare detailed technical specifications and financial proposals for each site in the project. It will also develop specific M&V plans customized to the particular requirements of each site and consistent with GZE's agreement with PSE. The ESCO will deliver these results to GZE which will submit them to the World Bank for lending approval and to PSE for agreement on the appropriate DSM resource payment. After these agreements have been reached, the ESCO will contract with each customer to secure its obligations of participation in the project, and arrange necessary project co-financing.

**6) Procurement, Installation, and Operation of Equipment**

After approval of proposed equipment by the World Bank, the ESCO will acquire the equipment according to the International Competitive Bidding (ICB) requirements of the World Bank. The equipment will be owned by GZE which will pay for it through the proceeds of the World Bank loan. The ESCO will arrange for equipment delivery and installation, after having conducted all necessary site preparation works. The ESCO will conduct all necessary equipment start-up and check-out tasks to ensure optimal operation. The ESCO will then operate and maintain the equipment over the lifetime of the pilot project.

**7) Monitoring and Evaluation**

The ESCO will install and monitor end-use load research equipment to establish a post-installation baseline of energy consumption data. It will also conduct all monitoring and reporting tasks specified in the M&V plans. The monitoring activities will focus on the full spectrum of technical, financial, and operational parameters. GZE will develop M&V and quality assurance and quality control (QA/QC) protocols to apply to project management and evaluation activities. Using the QA/QC protocols, GZE will conduct process and impact evaluations of the pilot project. Process evaluation focuses on how the project was implemented while impact evaluation focuses on the results that were achieved. Using the results of the evaluations, GZE will conduct an analysis of the feasibility and applicability of scaling the pilot project up to a full-size DSM program. GZE will submit the M&V results to PSE and the evaluation and scale-up results to the World Bank and USAID.

**8) Development and Implementation of Alternative Incentive and Delivery Mechanisms**

For the Phase 2 DSM activities following passage of the Energy Law, a number of energy efficiency opportunities are expected to become profitable to GZE which will then be competing for customers in the retail market. The motivation for its interest in this approach will be a combination of reducing its costs to PSE as well as providing service to its customers in a competitive market. Since there are a number of unusual aspects to implementing DSM in this context, compared to the more traditional approach, different DSM incentive, marketing, and delivery mechanisms will be developed and implemented. This work will be undertaken by GZE in close cooperation with the ESCO and participating customers in the pilot project.

**9) DSM Component of the Management Information System (MIS)**

GZE will fully integrate DSM data requirements into the "Informatics" MIS system (customer and geographic information systems) that is currently planned and which will be supported by the World Bank loan. Of primary importance to the DSM pilot project will be a "performance tracking and management system" that will collect and archive all project-related data associated with the participating customers, equipment acquisition, and cashflows.



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Other DSM components of the MIS will include market research information on customers, end-use metering data and direct load control capabilities, load forecasting inputs, and capabilities for telemetry with PSE for load and pricing data.

**10) DSM Technical Assistance (TA) to GZE**

Throughout the entire pilot project implementation, a broad TA program for GZE focused on DSM issues will be supported by USAID and the World Bank. It will be designed to provide GZE staff with the skills and capabilities to: 1) conduct economic and financial analyses of DSM investments, and IRP analyses, 2) develop end-use load forecasts, and end-use load research databases, 3) develop DSM program and contractor management skills, and campaigns to market DSM to customers, 4) design retail tariffs to provide DSM cost recovery, 5) develop M&V and QA/QC protocols, and 6) develop a long-term DSM business development strategy for GZE. Licensing and training on appropriate software products will be provided, e.g., products developed by the Electric Power Research Institute in the U.S. such as DSManager for DSM economic analyses, IRP-Manager for IRP analyses, and HELM for end-use load forecasts.

**11) TA for the Development and Training of Local ESCOs**

A special component of the TA to be supported by USAID will be training and business development assistance that will be provided to support participation in the pilot project of local Polish ESCOs and energy engineers. The training program will be modeled on one produced by USAID in other countries involving the curriculum and testing materials of the Association of Energy Engineers (AEE). Training workshops on different energy engineering topics will be offered by AEE and participants will be encouraged to take the Certified Energy Manager (CEM) examination. AEE will also attempt to establish local chapters in Poland from the training alumni. Business development assistance will focus on efforts to broker joint ventures between GZE's ESCO contractor and Polish ESCOs. The ESCO will be required to enter into such business relationships as part of the pilot project implementation. Polish firms will be identified as prospects and additional training and business advice

will be offered on topics such as corporate planning, financial planning, contracting, and business development.

**12) TA for the Development of DSM Resource Payments by PSE**

A special component of the TA to be supported by USAID will be assistance to PSE to develop the resource payments for DSM to GZE. Given the pilot demonstration nature of this project, it is expected that PSE will initially develop DSM resource payments as a "Standard Offer" instead of in a competitive bidding context. When the resource payment concept has been demonstrated with GZE and perhaps other distribution utilities, and when DSM implementation capabilities have been more fully developed in Poland, PSE could seek competitive bids for DSM resource payments in the future. Initially, PSE needs assistance: 1) to model the costs and benefits to PSE and the cashflow stream of the resource payments, 2) to develop the Standard Offer solicitation with associated contract terms and conditions, 3) to determine the appropriate M&V protocols necessary to verify that the DSM resources paid for are real, and 4) to produce educational documents and seminars to "sell" the DSM resource payment concept to the Tariff Committee, composed of representatives of the Polish Ministry of Industry and Trade, PSE, the generation companies, and the distribution companies, which has authority over all wholesale electric tariff issues in Poland. As the result of these activities, PSE will designate the internal staff resources required to implement a DSM resource payment program.

Schedule

Implementation of the DSM pilot project is expected to take place over the same period of time as other related activities under the World Bank distribution system loan to GZE, as described in the Aide-Memoire. The following schedule by task is consistent in this regard:

| Tasks | Responsible Parties | Schedule |
|---|---|---|
| (Project Decision) | Bank/USAID/GOP/GZE | 4/95 |



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| | | |
|---|---|---|
| 1) Develop TORs/PIU | Bank/USAID/GZE | 5/95-9/95 |
| 2) Identify Customers | GZE/Customers | 5/95-6/95 |
| 3) Contract ESCO | GZE/ESCO | 5/95-6/95 |
| 4) PSE Agreement | PSE/GZE | 6/95-9/95 |
| 5) Audits/Engineering | ESCO/Customers | 6/95-1/96 |
| (Project Appraisal/Approval) | Bank/GOP/GZE | 2/96-6/96 |
| (Loan Effective) | Bank/GOP/GZE | 9/96 |
| 6) Procure/Install Equipment | Bank/GZE/ESCO | 2/96-2/97 |
| 7) Monitoring/Evaluation | Bank/USAID/PSE/ GZE/ESCO/Customers | 11/95-5/97 |
| 8) Alternative Incentives | GZE/ESCO/Customers | 12/95-12/96 |
| 9) DSM Component of MIS | Bank/GZE | 9/96-3/97 |
| 10) DSM TA to GZE | Bank/USAID/GZE | 5/95-5/97 |
| 11) TA to Local ESCOs | USAID/GZE/ESCO | 9/95-9/96 |
| 12) TA to PSE | USAID/PSE | 6/95-12/95 |

Funding

It is expected that financial, grant, and in-kind resources to implement the DSM pilot project will be provided from the following sources:

- The World Bank will provide GZE with a US$ 5-15 million loan to finance the MIS equipment and a portion of the DSM equipment, and to pay for a portion of the TA.

- USAID will provide GZE and PSE with grant support for a portion of the TA, through the services of a contractor.



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- PSE will make resource payments for DSM that provides system benefits, and will pay for the activities of its staff and associated overhead expenses of developing the resource payments.

- GZE will pay for the activities of its staff and associated overhead expenses of establishing and running a DSM Unit.

- GZE's ESCO contractor will finance a portion of its technical services and a portion of the DSM equipment.

- Participating customers will finance a portion of the ESCO's technical services and a portion of the DSM equipment.

- The ESCO will arrange additional financing of the DSM equipment from third-party sources of debt and equity.

## Staffing and Management Plan

The World Bank will have primary responsibility for reviewing and approving all documentation associated with DSM loan activities. The Bank will manage relations with the Government of Poland (GOP), working in close coordination with USAID, which will be responsible for supporting the bulk of the technical assistance activities, through a contractor.

The primary management responsibility for implementation of all components of the DSM pilot project will reside with GZE, the recipient of the World Bank loan proceeds. GZE will establish a PIU and designate a Project Manager for this purpose. GZE will direct all of the ESCO's activities through a contract, and will manage all contacts with its customers, either directly or indirectly through the ESCO. Within this context, the ESCO will contract with GZE's participating customers and sources of project co-financing, and will arrange equipment procurement.

PSE will initiate the Standard Offer process for DSM resource payments, and will contract with GZE for that purpose.

# CENTRAL AND EASTERN EUROPE
# REGIONAL ENERGY EFFICIENCY PROJECT
# EUR-0030-C-00-2053-00

**Energy Pricing, Energy Efficiency, and**
**Energy Sector Restructuring Component**

**Bulgaria**
**Electricity Action Plan**
*Task Completion Memorandum*

*Prepared for:*

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August 1996

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# CENTRAL AND EASTERN EUROPE
# REGIONAL ENERGY EFFICIENCY PROJECT

*Task Completion Memorandum*

***Bulgaria - Electricity Action Plan***

## Summary Task Description

In 1992, Bulgaria had installed capacity of 12,000 MW. The annual electricity generation is from the following sources: about one-third from the Kozloduy nuclear power station, one-third is from thermal plants firing indigenous coal and lignite, one-quarter from thermal power stations firing imported coal, and the remainder hydroelectric. Imports make up 10% of the electricity balance. The sector was reorganized in 1991. The Committee of Energy (COE) is a government organization that controls the National Electric Company (NEK), which is a joint-stock company wholly owned by the government. The electric energy intensity of Bulgaria's economy is high relative to other countries. This has resulted from national development policies and electricity pricing policies. The environmental impact of the electricity sector appears to be severe, with substantial sulfur and particulate emissions from the thermal power stations. The risk of serious problems with the older units at Kozloduy also appear to be higher than the newer Soviet-designed pressurized water reactors. Bulgaria's electricity sector is coming under increasing pressure to improve efficiency. These pressures are building from within the country, resulting from democratic reforms, the transition to a market economy, and higher electricity tariffs. The study will be coordinated with the work of EC-funded consultants. EC consultants will work in generation and transmission. Hagler, Bailly worked in areas of organization, demand, and environmental (thermal power plants).

This task assisted the National Electric Company (NEK) and Committee on Energy (COE) to prepare an action plan for Bulgaria's electric power sector, including an institutional reform strategy, proposed programs, and an investment plan. The activity focused on 1) structural, institutional and organizational reform in the electricity sector and the NEK, 2) electricity demand forecasting; 3) assessment of the potential for demand side management; 4) thermal power generation environmental impacts and related issues, and 5) promotion of private sector participation in power generation. This task was a joint effort with the European Commission.

## Specific Goals and Objectives

To develop an electricity action plan with special emphasis on restructuring the national electricity company, improving its management efficiency and environmental performance.

## Expected Outputs

Organizational Reform Report, Demand Side Management Report, Demand Forecast, Environmental Report, Private Power Assessment Report

## Deliverables

Hagler Bailly provided short term consultants, field trips, workshops, analysis, and produced a number of reports which address the Bulgaria Electricity Action Plan task. A summary of the deliverables completed by Hagler Bailly is the following:

- A report on *The Electricity Subsector of Bulgaria Organizational Issues and Structural Options, August 1993*, which addressed the fundamental organizational and structural issues affecting Bulgaria. This report contains analysis and recommendations in seven principal areas:

  - Corporate organizational considerations
  - Board of branch managers
  - Corporate governance and regulation
  - Organizational recommendations
  - Central dispatch recommendations
  - Structural recommendations
  - Regulatory recommendations

- A report on *Demand Side Management Assessment, November 1993,* which provided an evaluation of the DSM potential in Bulgaria and recommendations on DSM program implementation. The key provisions of the report are:

  - Results of industrial energy audits
  - Review of demand forecast
  - Creating a policy framework (IRP, tariffs, private power)
  - Development of an illustrative DSM program
  - DSM action plan

- A report on *Electricity Demand Forecast, February 1994,* which provided a demand forecast for Bulgaria and compared the high and low case.

- A report on *Independent Power Generation in Bulgaria: Assessment of Potential, Impediments, and Options, August 1993,* was prepared that (1) reviewed the status of Bulgaria's economy and investment climate; (2) characterized the independent power market with a focus on repowering existing thermal, cogeneration, and district heating capacity, (3) reviewed the successful independent power policy development experience of the U.S., Spain, Argentina, and Poland; (4) reviewed the structure and sources of independent power project finance; (5) reviewed the overall relevant legal and institutional framework, and (6) provided extensive recommendations regarding the policy and institutional changes needed to attract private power investments.

- Based on the conclusions of the *Independent Power Report,* a two day workshop was organized which included participants from all relevant institutions. At this workshop, presentation were made summarizing the conclusions of the report. On the second day of the workshop, a case study was discussed in a role-playing exercise. All the participants split into four working groups (the utility, the developer, the government, and the bankers) and played their respective roles in a mock negotiation. This exercise was highly successful in communicating to the Bulgarian government and industry the key issues involved in independent power project development.

- A report on *Power Sector Environmental Issues, December 1992,* which provided an environmental assessment of six thermal power plants in Bulgaria. The report looked at existing emissions and control systems, which state-of-the-art environmental technologies could be implemented, and the potential reduction in emissions if environmental mitigation measures were adopted. The report developed a strategy and made specific recommendations for the six thermal plants, and the country's generation sector as a whole.

These deliverables comprise Hagler Bailly's contribution under this task.

**Results and Next Steps**

The following results were obtained under this task:

- *Electricity Action Plan* - The report was circulated among key Bulgarian energy agencies and donor agencies. While the report was generally well received, NEK decided to solicit alternate recommended approaches from EdF, NERA, and others. This provided them with a full range of models, country experiences, and recommendations for restructuring. To date, NEK has not acted on adopting any particular model or approach, and does not have any near term plans to do so. NEK plans to remain an integrated utility but also

intends to decentralize some of their operations and continue to move prices up to commercially sustainable levels.

- *Demand Side Management* - NEK has incorporated the demand forecast and demand side management program in their current least cost power systems plan. They plan to encourage all customers to adopt DSM programs and technologies through information dissemination campaigns and through tariff increases.

- *Independent Power Generation* - NEK has released several solicitations for IPP developers to lease and operate/maintain several power stations on a long term basis. These solicitations have produced several tender offers, but the proposed cost of bulk power has been much too high, approximately 50% higher than current cost from NEK owned plants.

- *Environmental Issues* - The report was well received and the findings will be incorporated into future rehabilitation projects.

This task has resulted in the following principal actions by NEK and the Ministry of Energy (formerly Committee on Energy):

1. DSM and environmental issues have been incorporated into NEK's power development program. The utility recognizes the value here and intends to promote DSM and environmental issues as a matter of company policy.

2. Independent power generation projects will be pursued, and NEK has abandoned any plans to construct future power stations.

3. NEK intends to remain an integrated utility for the near future, but the electricity action plan of USAID has given them future restructuring options to consider as they move to a more commercial basis for operations.

There are several areas in which NEK and the Ministry of Energy need to take action:

*1. The first is bridging the gap* between DSM planning (which is done at the utility level and incorporates DSM in least cost power development programs) and the implementation of such programs at the customer level. NEK views their responsibility as ending on the 'supply side of the meter', and has no plans to become involved in implementation. This leaves a wide gap since few industrial customers are cognizant enough of DSM programs and technologies to pursue them on their own. Additionally, few customers are aware of NEK's overall power supply planning process and have no ownership of it. The result is that NEK is incorporating a certain level of capacity to be supplied by DSM, but is doing relatively little to ensure it happens.

*2. The second area concerns IPP developers.* NEK's initial public offerings produced tenders that were approximately 50% higher than NEK's current cost of bulk power, making the offers unattractive for the near term. NEK needs to look into these tenders in detail and determine why the cost is so much higher, and what can be done to mitigate the difference so IPP projects will be viable in Bulgaria.

*3. Finally*, the structure of the power sector should be further evaluated to determine of a fully integrated structure is best, or if an unbundled and competitive structure would succeed in introducing efficiency and market forces to bring down costs. This would be a long term objective.

# THE ELECTRICITY SUBSECTOR OF BULGARIA ORGANIZATIONAL ISSUES AND STRUCTURAL OPTIONS

*Final Report*

*Prepared for:*

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- C.5 Summary Outline of Draft Law for Generation, Transmission, and Destination of Electricity

Appendix D Detailed Analysis of Structural Options

## Exhibit 1-2
## Summary of Recommendations

| Exhibit | Recommendation |
|---|---|
| **Recommendations for the Corporate Finance Division** | |
| 2-2 | Implement basic budgeting and control concepts and information systems |
| 2-2 | Estabish a formal financial planning process |
| 2-2 | Implement improved cash management systems |
| 2-2 | Update and formalize the policy and procedure manuals for the accounting and finance function |
| 2-2 | Establish an internal audit function |
| 2-2 | Expand resources as necessary to develop a professional account and finance function |
| 2-2 | Upgrade basic accounting system |
| **Recommendations for the Electricty Supply Branches** | |
| 2-3 | Consolidate the 28 existing branches into a smaller number of larger branches |
| 2-3 | Initiate a program to increase the company's control of meters |
| 2-3 | Use caution in evaluating the acquisition of advanced meter reading technologies |
| 2-3 | Separate the reporting of transmission losses from distribution losses |
| **Recommendations for the Development and Investment Division** | |
| 2-4 | Consider consolidating the division with a newly formulated corporate planning function |
| **Recommendations for the Generation Division** | |
| 2-5 | Expand the size and responsibilties of the headquarters staff |
| 2-5 | Study the possibility of establishing the nuclear operations as a separate division |
| **Recommendations for the Legal Department** | |
| 2-8 | Explore the possibility of consolidating more of these attorneys at the headquarters |
| **Recommendations for the Office of the President** | |
| 2-9 | Develop and implement an automated executive service information system (EIS) to facilitate the monitoring of key orders of the Supervisory and Managing Boards |
| **Recommendations for All Departments** | |
| 2-9 | Consider consolidating this function under a vice president of administration |
| **Recommendations for the Personnel Department** | |
| 2-10 | Implement a project to automate the company's personnel records |
| 2-10 | Consider expanding the scope of responsibilities of the Personnel Department |

skills, tools and techniques will be enhanced by the implementation of profit centers in the power plant and distribution segments of the utility. Once accomplished, the organization will be better prepared to adapt to the next series of changes.

The next steps will involve a process outlined in chapter 4 of this report. The process involves a series of activities that will result in identifying and implementing the structural alternative that represents the "best fit" with the needs of Bulgaria electricity supply subsector.

- The success of the structural option selected will depend, in large measure, on achieving consensus among key managers at COE and NEK as well as backing by the government.
- This may warrant the creation of task forces to address these issues and achieve a consensus selection.
- After that, the conceptual structure must be converted into a workable design for NEK.
  - This will require developing a detailed organizational design and implementation plan and schedule to achieve it.

However, this consensus approach should not be allowed to become a long drawn-out process. The detailed organization structure that is ultimately identified will probably take a few years to be fully implemented. But the first step — identifying a workable "best fit" — can and should be done expeditiously.

### 1.4.7 Regulatory Recommendations

Chapter 5 describes the current status of regulation in Bulgaria with an outline of major regulatory initiatives required in Bulgaria, including:

- Economic
- Environmental
- Nuclear

# 1.0 BULGARIAN ELECTRICITY STUDY FINAL REPORT

## 1.1 BACKGROUND AND PERSPECTIVE

The electricity subsector of Bulgaria's economy is in the midst of historic change. The sector is moving away from the former command economy and adapting to the needs of a competitive market economy. In line with these changes the Committee of Energy (COE) and the National Electric Company (Nationalna Elektricheska Kompania, or NEK) are faced with the need to develop an organization structure for NEK that will best serve its needs under changed market conditions now and in the future.

Until recently, all energy matters in Bulgaria were consolidated under one governmental ministry. In January of 1992, Bulgaria's National Electric Joint Stock Company (NEK) was formed. It is wholly owned by the Government and reports to the Committee of Energy (COE) and the Council of Ministers through a Supervisory Board; it is managed by a Managing Board, headed by the President of NEK. As of the time of our study, NEK was organized, as shown in Exhibit 1-1.

### BACKGROUND AND PERSPECTIVE

The National Electric Company of Bulgaria, is a joint stock company wholly owned by the state. An integrated electric utility company, NEK is responsible for the production, transmission and distribution of electricity and the production and sale of heat. The company was established by Decree No. 46 of November 7, 1991 of the Council of Ministers of Bulgaria. NEK's assets amount to about 100 billion leva (U.S. $4 billion). The company had total net energy generation of about 41 million MWh and a peak demand of 7,489 MW during 1991. Its 1991 total installed capacity was 12,074 MW, of which about 86.5 percent was company-owned with the balance owned by district heating companies (4.9 percent of the total) and industrial producers (8.6 percent of the total). NEK's (company-owned) capacity mix is as follows:

| Capacity | MW | % |
|---|---|---|
| Nuclear | 3,760 | 36 |
| Thermal | 4,730 | 45 |
| Hydro | 1,970 | 19 |
| **Total** | **10,460** | **100.0** |

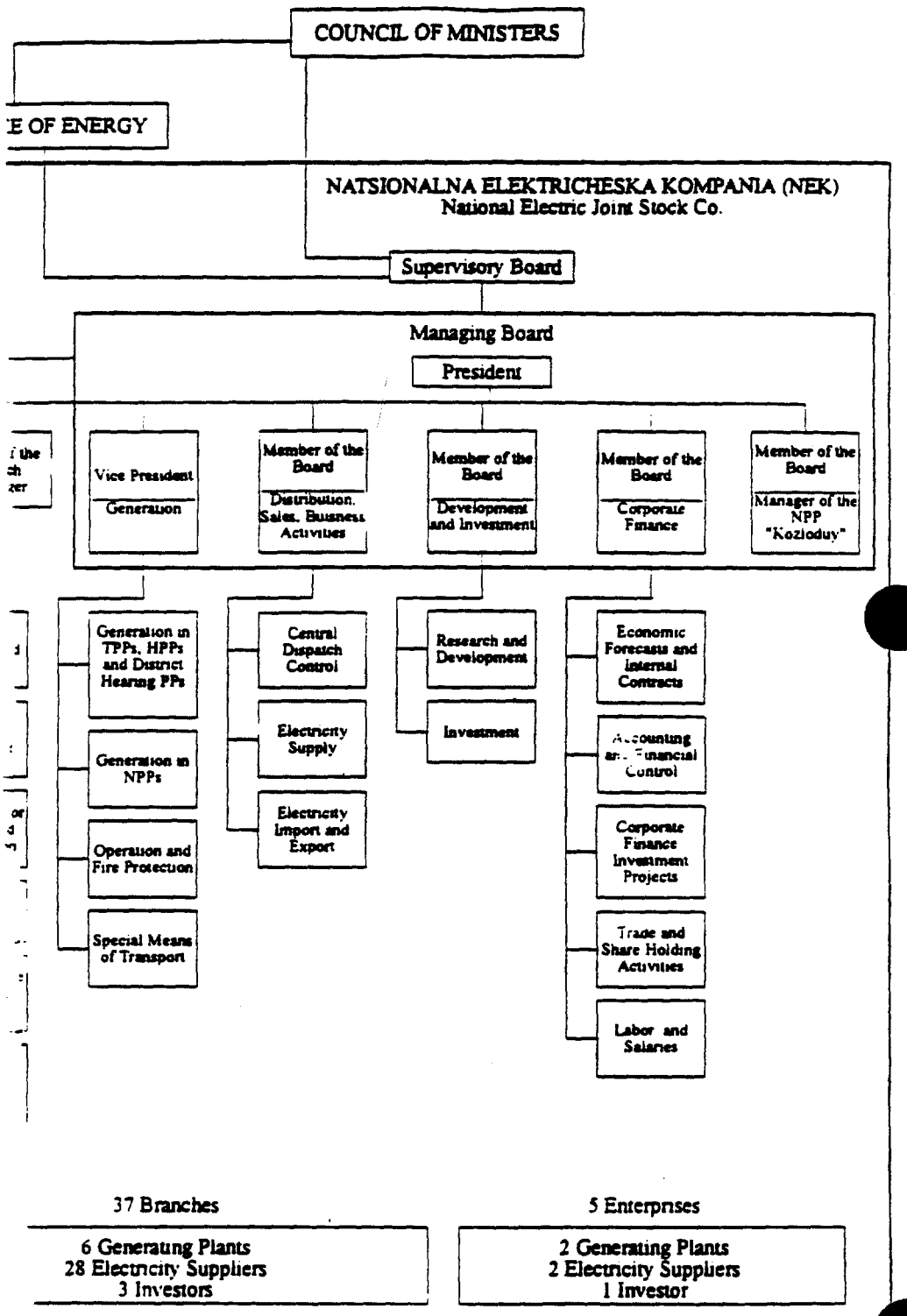


Figure 1-1 NEK Organization Chart

The company is operated through a network of 28 electricity supply branches and ten generation branches with total staffing of about 30,000. NEK's headquarters was formed in January 1992. Based in Sofia, the headquarters function has a staff of about 200.

- NEK currently operates more like a confederation of generation, transmission, and distribution entities than as a unified and tightly controlled organization.

The underlying motivation for this study is that NEK needs to improve the productivity of all its physical resources and human resources. In a market-driven business environment there will be an intensified need to produce the highest quality results at the lowest possible cost. As a key element of Bulgaria's economic infrastructure, NEK's achievements will have a potentially profound effect on the competitiveness and general economic well being of its customers.

- The recent increases in electricity prices were necessary to eliminate subsidies and bring prices into line with the cost of providing service.

- This places even greater pressure on NEK to improve its efficiency and effectiveness.

  - Higher pricing requires that NEK provide the best possible value for its service.

A recent review of the electric power business in the United States and Western Europe revealed that major structural changes are planned or underway in every country. Furthermore, they involve almost every company in the power business. Three elements of these changes include:

- The development of strategic business units (SBUs) including, in many cases, the implementation of the profit center concept.

- Consolidation of common functions to eliminate duplication and achieve economies of scale.

- Productivity improvement programs to improve quality and reduce costs.

While NEK's situation is unique in comparison to its counterparts in the West, it too must respond to similar — and in many respects, greater — challenges in its own market place. This represents a radical departure from the past.

- But NEK's need to find an appropriate organization structure occurs as it is struggling with a flood of operational, financial and political problems.

- Whatever form of organization is pursued must not further complicate a management situation that is already challenging in the extreme.

- Consequently, NEK would likely be best served by the solution that is simplest.

- And NEK is at the point where -- to paraphrase a leading organizational theorist -- the effective implementation of the selected structure (i.e., from among the finalist candidates) will be more important than the structure itself.

There are some other important considerations affecting decisions about NEK's organizational structure. Chief among them are the legislative framework governing commerce in Bulgaria, including a determination regarding the form of ownership (i.e., privatization) and how it will be implemented, and some clarification regarding the regulatory framework for the electric utility subsector

The recommendations regarding organizational efficiency and structure that are ultimately adopted for the National Electric Company will be influenced in large measure by how the company's mission is defined. This is a very important task that must be confirmed by the Committee of Energy and the National Electric Company. For this study, we have crafted a mission statement for NEK that reflects the essence of those adopted by most electric utilities in the West and that is consistent with our understanding of the intent of COE and NEK regarding the electricity subsector. This mission is:

- *To provide an adequate supply of electricity at the lowest achievable cost consistent with safe, reliable and environmentally responsible operations that are in compliance with applicable laws and regulations and that serve the interests of stakeholders, including customers and employees while earning profits that are sufficient to achieve and maintain financial viability.*

## 1.2 OBJECTIVES AND SCOPE

This report examines the alternative ways that Bulgaria can structure its electricity subsector. It outlines the criteria used to evaluate alternative structural choices, describes the attributes of optimum structures, defines the structural alternatives identified by our analysis, discusses their advantages and disadvantages, identifies a subset of options for final consideration and outlines a process for COE and NEK to develop the "best fit" structure and that can be used to guide NEK's implementation of structural changes.

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In order to accomplish an assessment of the structural options, our study included a general survey of the current organization. The results of this general survey form the basis for a number of recommendations for improvement. Two other issues of special interest are also included in this report. They are central dispatch and regulation.

## 1.3 OVERALL OBSERVATIONS

Organizational effectiveness is a key ingredient to achieving better business results. RCG/Hagler, Bailly does not believe that there is one and only one "right" organizational configuration possible for NEK. However, we know from experience that this does not mean that every possible organization structure will be equally effective.

- In short, NEK needs to analyze itself and adapt its organization structure to improve its effectiveness, enhance efficiency and prepare itself for the rigors of a dynamic market economy.

- A clear vision of where NEK and the electricity sector as a whole are going in the next few years needs to be developed; this vision must include a definition of the company's mission. It also needs to be supported by the Council of Ministries, the Committee of Energy and NEK's management.

- The organizational structure of both the electricity sector and the company should be viewed as evolutionary rather than revolutionary. The best possible structure may not be achievable immediately, but a practical, more efficient structure is within grasp.

The structural options that would keep some or all of the existing generating plants vertically integrated with the transmission/central dispatch activity dominate the others included in our initial analysis. Although the final form of structure offers other options, including more decentralized variations, the selection of the "best fit" structure will hinge on some important pragmatic considerations. Three of the most important constraints that must be accommodated by the structure selected for Bulgaria's electricity subsector are that the structure must:

- Maximize efficiency and enable the company to become a low-cost provider

- Facilitate the raising of the substantial amounts of external capital required for the foreseeable future

- Provide the ability to manage the risks associated with NEK's nuclear power plant

- The reality NEK must face is that the Kozloduy nuclear power plant is widely considered to be one of the unsafest of the nuclear plants operating in Europe.

- Consequently, an important consideration relates to the perception afforded the new structure. Whatever structure is selected, it must give assurance and comfort to key constituencies (Western governments and major international lenders) that it provides acceptable (i.e., very high) assurance of being able to safely operate and maintain the plant.

The ability to satisfy these three constraints is critical to the acceptability of the structure selected. In fact, the overriding constraint is the business risk associated with the company's Kozloduy nuclear plant. If the structure adopted for the electricity subsector does not adequately deal with the nuclear issues it will affect the company's ability to raise external funds. Indeed, it is clear that if a structure that is deemed unacceptable (i.e., by the world banking community and those Western governments providing aid and financing to Bulgaria) is even seriously considered, it will likely invoke serious reaction. In this area, the structure must be perceived as satisfying the nuclear risk considerations.

- Given the scale of potential liability associated with nuclear operations, an independent and privatized nuclear generating company is inconceivable in Bulgaria at this time.

  - This could not even be accomplished as part of the privatization scheme implemented in the United Kingdom.

- The potential liability for physical injury and property damage in the event of an accident pose risks that may dictate continued government ownership at least of the nuclear generation.

  - This may, in turn, oblige many of the remaining assets of the company to remain under government ownership.

- In addition to this exposure, there are enormous known and potential business risks associated with replacement power in the event of a forced outage due to an accident and the highly uncertain decommissioning costs for Kozloduy.

- How and when the nuclear issues associated with the Kozloduy nuclear plant are resolved, will determine when — and perhaps whether — COE and NEK may implement certain of the structural options identified in the study.

- In the longer run, these assumptions probably should be reexamined and reevaluated.

  - But, given NEK's financial condition, including its compelling need for capital as well as the need to develop its management skills, systems and organizational infrastructure, there may not be any alternative to some variation of this trade-off.

  - After the company is "on its feet," the most important focus should be profitability and service quality. These will be best served by an organization design that reflects the lessons learned from the competitive market economies in the United States and Western Europe.

  - However, until the nuclear issues are widely considered to be under more satisfactory control than at present, some form of continued governmental involvement appears to be unavoidable.

  - Realistically though, government involvement probably means continued ownership of the utility either completely or partially.

- The central implication of these constraints is that, for the foreseeable future, NEK will not have a completely free hand to adopt the structural options identified in this study.

Any structural option selected needs to be tested against some basic decision criteria. In fact, these criteria can be applied to each stage of the evolution of the organization and structure. The criteria and our overall assessment are as follows:

- **Risk.** This requires a subjective judgment to weigh the expected gain against the risks associated with implementing any given alternative approach.

- **Economy of Effort.** What option will likely produce the greatest result for the least cost and the least disturbance of the organization?

- **Timing.** Does this decision need to be completed swiftly to impose a new vision? Or does it require a moderate pace to allow the organization to develop the new skills and habits necessary for success?

- **Limitation of Resources.** The most important of the resources to be considered are the human resources necessary to implement the decision,

especially the limited time and capabilities of the collective organization to implement the changes effectively.

Our summary conclusion is that NEK needs to pursue a course of action with a high-probability of success. The organization is already dealing with a blizzard of changes and — here more so than in most situations — the simplest solution is likely to be the best. The human resources in the organization appear to be overextended in their efforts to cope with the many new requirements of transforming NEK into a competitive, market oriented organization. Given the scale of the new systems, procedures and management disciplines to be developed or implemented, we believe a moderate pace to restructuring would be appropriate.

In summary, we suggest that an effective transition structure would be an organization that maintains (mostly) the integration of generation, transition and distribution activities while introducing elements of profit making enterprises in competitive market economies.

- Basically, this structure is a variation of the holding company form of organization in the electric utility industry in the United States.

- Essentially, this approach is predicated on the belief that those activities that do not require corporate-level decision making should be delegated to the lowest possible level of the organization. Operational management issues are left, to the maximum extent feasible, in the hands of operational managers.

- In effect, it blends the concepts of competitive market enterprises with the vertically integrated utility. Given the relatively small size of Bulgaria, this would also involve a horizontally integrated company.

- One advantage is that it could be built largely on the existing branch network of the National Electric Company.

Under this organization, certain rights and powers are reserved exclusively for the headquarters with all remaining operational matters the responsibility of the decentralized branches.

- Profit centers would be established for the generating plants and each of the distribution branches.

- Ownership would be unified through the holding company which, in turn, could be either state-owned or privatized.

However, the issue of privatization, as discussed above, will remain somewhat problematic until the issues related to the Kozloduy nuclear generating station are resolved. In addition, the infrastructure related to commercial law and regulatory oversight would need to be further developed.

- The key consideration in implementing the holding company concept is identifying what should be centralized at the holding company level.

- That is to say, what matters have a corporate-wide impact and should be reserved for the centralized headquarters management?

All things considered, this approach seems to offer a relatively low-risk approach to developing a competitive, market-oriented organization. However, one common error in organizational planning is to assume that the work is complete once the organizational charts have been drawn up. An organization redesign of any significance constitutes a major change. The questions of implementation are not trivial. Policies, methods, systems and reporting relationships need to be altered. Individuals and groups have to be motivated to continue to perform in the face of major turbulence.

Therefore, in this phase, it is important to identify the key implementation issues, develop a plan and then execute that plan to ensure the objectives are achieved. The implementation process that we reviewed and discussed with COE and NEK follows consists of two major phases:

- **Phase I.** First, NEK should implement fundamental improvements in its management systems, procedures and practices and concurrently organize the company into profit centers under the holding company form of organization.

- **Phase II.** After the foundations have been laid to improve the results of operations, COE and NEK can then proceed to implement certain other structural changes to further enhance the competitiveness of the electricity subsector.

- Certain aspects of Phase II could be accelerated if circumstances warrant it. Specifically, a small-scale IPP pilot program could be initiated as a vehicle to learn how to implement this technique later on a larger scale.

This represents a gradualist approach that will allow NEK's management to develop the organization's ability to compete more effectively in a market economy. These basic skills, tools and techniques will be enhanced by the implementation of profit centers in the power plant and distribution segments of the utility. Once accomplished, the organization will be better prepared to adapt to the next series of changes.

## 1.4 SUMMARY OF RECOMMENDATIONS

### 1.4.1 Corporate Organizational Considerations

Our observations in this area can be classified as follows:

- **Corporate Planning.** NEK does not have a separate corporate planning function. Certain elements of the corporate planning process are conducted in different parts of the organization, including the Corporate Finance Division and the Development and Investment Division. As the company continues to move toward becoming a market-oriented company, the role of planning will become more important to NEK's success.

  As part of a review of its organizational requirements, the company should consider establishing a formal corporate planning function.

  - This could be combined with certain other functions (e.g., financial planning or control budgeting) or it could be set up as a stand-alone group.

  - The company should be also ensure that it has adequate resources to do its job properly, including trained staff, computers and models.

- **Customer Service and Marketing.** NEK does not have a separate customer service and marketing function. In a market-oriented economy, these will become much more important to NEK's success. Its customer services should be expanded to encompass dealing with customer problems and complaints in a timely, responsive and helpful manner. NEK's marketing function would be the focal point for its demand-side management programs as well as for developing competitive strategies to enhance corporate profitability through cost-effective marketing programs.

  Both of these functions should be given serious consideration by NEK.

  - Customer services will be carried out by the field organization (the electricity supply branches), although there should be a single point of responsibility at the headquarters level to set policy and establish procedures to ensure that service delivery standards are met on a consistent basis.

  - Marketing should be a headquarters function.

- **Management Information Systems.** NEK information systems resources are somewhat fragmented. At the headquarters level, the company's systems are microcomputers. Data processing services to support certain operational activities (e.g., accounting, billing and collection) as well as certain planning activities (e.g., load forecasting) are provided by outside agencies including Energoproekt and Energokibernetika.

  Although the company may ultimately conclude that this management system works well for it, NEK should nonetheless take stock of its information systems needs and develop an information technology plan.

  — This is particularly pertinent given the need to implement some large-scale systems.

- **Fuels Planning and Management.** With fuel costs being the largest component of operating cost, this area warrants attention from a specialized department.

  — This group may be best established as a separate entity within the Generation Division.

  — However, it should be composed of experts in the technical and contractual aspects of fuels.

- **Performance Measurement Systems.** One of the most important tools NEK can use to improve the results it achieves is to establish a formal performance measurement system. Performance indicators can be set for every area of the business as well as for the overall corporation. Some of these indicators or ratios can be specific to a sub-unit of the company (e.g., customer service indicators) or they can be based on a panel of peer companies or a "model" company.

  Performance indicators or benchmarks should be set for as many areas of the company as possible. The actual results should be monitored and reported monthly to the operating management of the associated function, with a compilation of all results (in summary form if it becomes too voluminous) reported to senior management, perhaps through an automated executive information system (EIS).

  **Productivity Systems.** One of the company's top priorities should be to improve the productivity of all of its resources including labor, key physical resources, capital, and the knowledge and experience of its management. NEK can set up an internal group to focus on this area. This group would

basically constitute an internal consulting department. This group could be used to conduct internal reviews of various operating units and to work with that group's management to improve productivity. Such a group could also conduct corporate-wide studies or develop comparisons of NEK's operations with other electric power organizations.

### 1.4.2 Board of Branch Managers

NEK has a Board of Branch Managers that is composed of the managers of its 42 branches (at present, 28 electricity supply branches, 5 investors, and 9 power plants). This group's charter is to provide advice and counsel to the Managing Board, and to notify the Supervisory Board if it concludes that the Managing Board has exceeded its authority. There is a wealth of experience and expertise on this Board of Branch Managers, yet there is a tension between the two boards because of the inherent competition for decision-making authority.

- NEK should explore ways to improve its use of this group.
  - It could draw from this group to establish task forces or committees to address special problems.
  - It could also consider appointing a vice president of field operations from this group to serve in a similar capacity as the vice president of generation.

### 1.4.3 Corporate Governance and Regulation

NEK was constituted from various elements of the Committee of Energy (COE), the state energy organization. Especially since NEK continues to be wholly-owned by the state, there is close relationship among NEK, COE, and the Supervisory Board. There are some organizational tensions among these three bodies, and occasionally overlapping responsibilities and even conflicts. In addition, there a number of regulatory agencies overseeing various aspects of NEK's activities including price-setting and nuclear generation, among others.

- As NEK continues evolving, it will need to give special attention to these relationships and to ensuring that effective interfaces are developed.
- The exact nature of these corporate interfaces will be influenced by the ultimate form of organization NEK adopts and by its form of ownership.

| NEK Division/Department Profiles | LEGEND | Exhibit 2-1 |
|---|---|---|

## GENERAL DESCRIPTION

A description of the unit's general responsibilities.

## CURRENT STRUCTURE

An outline of the structure of the unit.

## KEY COORDINATING MECHANISMS

A description of the mechanism or technique for coordinating and controlling work to accomplish desired results, e.g., direct supervision, standardization of work, standardization of skills, standardization of outputs.

## DESIGN PARAMETERS

**Work Specialization** - Indicates the degree to which work activities are specialized and require specialized education, training, and/or on-the-job experience.

**Training and Indoctrination** - A description of the nature of training and indoctrination conducted by the organization.

**Formalization of Activities** - Indicates where the organization exists on the scale of highly formalized (bureaucratic) to unstructured (organic).

**Unit Size** - Indicates the relative size of the organizational work units.

**Planning and Control Systems** - Describes the nature of the planning and control mechanisms used to manage the organization's work.

**Liaison Devices** - Describes the nature of the communication and coordination mechanisms required to interact with other departments/divisions.

**Scope of Authority** - The amount of decision making authority (vertical and horizontal). Indicates where the unit sits on the centralize-decentralize continuum.

## OBSERVATIONS AND CONCLUSIONS

Includes a discussion of pertinent aspects of the current organization structure, staffing, resources, management processes and practices, or information systems.

## RECOMMENDATIONS

Discusses specific recommendations for improvement.

**A Note on Scope:**

Our review of the NEK was in the nature of an initial survey. The objective was to develop a working knowledge of the company and its major organizational units sufficient to make basic recommendations. The scope did not include a comprehensive and detailed operational audit of every organizational unit. Consequently, this report focuses on those major issues that we observed during the course of our survey. A detailed management and operations audit would likely identify more — and more detailed — recommendations. Furthermore, most of the recommendations presented herein require some further elaboration or analysis as part of an implementation program. These activities should be performed by NEK.

## 2.0 THE CURRENT ORGANIZATION

At present, NEK is organized into divisions and departments. The divisions consist of multiple organizational units, while the departments are single-unit organizations. The divisions include Corporate Finance; Distribution, Sales, and Business Activities; Development and Investment; Generation; and Manager of the Nuclear Power Plant (NPP) "Kozloduy."[1] The departments include Administrative and Public Service, Foreign Relations and Protocol, Legal, Office of the President, Personnel, and Preparation for Defense. The Central Dispatch Department is an important part of the Distribution, Sales, and Business Activities Division. The complex nature of its activities warranted separate treatment. Chapter 3.0, Organization of the National Dispatch Center, presents the findings of that study. The balance of this chapter consists of a series of exhibits profiling NEK's current organization.

- A legend, giving an explanation of the contents of each profile, is detailed in Exhibit 2-1. It describes the main headings included in each profile: a general description, an outline of the current structure, a listing of key design parameters that can assist in evaluating and/or modifying the current structures, and any observations, conclusions, and recommendations developed during the course of our work. The profiles are presented as follows:

| Exhibit Number | Division/Department Profile |
|---|---|
| 2-2 | Corporate Finance Division |
| 2-3 | Distribution, Sales, and Business Activities Division |
| 2-4 | Development and Investment Division |
| 2-5 | Generation Division |
| 2-6 | Administrative and Public Services Department |
| 2-7 | Foreign Relations and Protocol Department |
| 2-8 | Legal Department |
| 2-9 | Office of the President |

[1] The Manager of the NPP Kozloduy Division (a member of the Board of Managers) is discussed in Exhibit 2-5 on Generation; the Preparation for Defense and Mobilization Department (a relatively minor function at NEK) is not discussed further here.

## GENERAL DESCRIPTION, cont.

**Accounting and Financial Control** - The responsibilities of this unit, which has a staff of eight, include:

- Determining financial and accounting policy for all (42) branches of NEK.
- Overall responsibility for the books and records of account of the corporation, including responsibility for collecting information from all departments and preparing the consolidated financial statements of the NEK.
- Implementing and ensuring compliance with the Bulgarian Accountancy Act.

**Corporate Finance Investment Projects** - The responsibilities of this unit include:

- Examining and proposing financing options and alternatives.
- Monitoring the company's capital structure.
- Working with credit agreements and international financial institutions.
- Preparing for international competitive bidding, including the preparation of draft contracts, etc.
- Monitoring cash flows, with assistance from the Accounting and Financial Control unit.
- Investment project appraisal.

**Trade and Share Holding Activities** - This unit is responsible for accounting for certain trading activities, including the import/export of electricity, machinery, and equipment. The department organizes, carries out, supervises and coordinates trade operations within the system of NEK by implementing the activities listed below:

- Marketing studies in:
  - energy carriers
  - machines and equipment
  - consumables
  - spare parts, etc.

**Division Profile** **CORPORATE FINANCE DIVISION** **Exhibit 2-2**

## GENERAL DESCRIPTION

The Corporate Finance Division is composed of five units, with the following responsibilities:

**Economic Forecasting and Internal Contracts** - The responsibilities of this unit, which consists of a staff of eight, include the following:

- Conducting financial analysis, including calculation of the company's financial ratios and analysis of the results of operations.
- Determining the company's revenue requirements.
- Developing forecasts of business indicators and business results, including electricity demand (done in conjunction with the Dispatch Center and the Generation Department). On a monthly basis, this unit estimates NEK's revenues and expenditures, including depreciation, maintenance expenses, and salaries and labor costs. The results of these estimates are provided to the Accounting and Financial Control unit.
- Participating in the development of the corporate strategic plan, including setting goals and financial (ratio) targets for the next five years.
- Estimating total electric supply, including production and purchases. This estimate is updated quarterly.
- Monitoring financial markets.
- Maintaining banking relationships, and conducting negotiations for loans, lines of credit, etc.
- Determining the expenditures of all generating stations.
- Overseeing the domestic contracts and settlement protocols between the company and the electricity supply branches.
- Monitoring cash flow requirements, including determining short- and long-term requirements and the amount and timing of external sources of funds.

**GENERAL DESCRIPTION, cont.**

- On the basis of compiled requests from other departments of the Company, collects price and technology information from various suppliers and offers the data acquired to respective specialists.
- Analyzes the information collected, evaluates the market studies and strictly implements the Procurement Rules of NEK.
- Selects the most favorable technical and price offers.
- Develops plans/scenarios of negotiations.
- Negotiates trade and financial terms.
- Defines contract clauses.
- Participates in technical discussions and leads the discussions on prices and delivery terms.
- Draws up agreements and submits them for review by the Managing Board of NEK.
- Keeps the original copies of contracts concluded.
- Follows up execution of contracts concluded.
- Prepares the payment documents and transfers them to the Accounting Department for settlement of foreign and local currency payments.
- Arranges for shipment of contracted goods in compliance with the contracts signed.
- Secures issuing of licenses in compliance with law regulations.
- Prepares customs clearance documentation for the goods.
- Monitors receipt of contracted goods by end users.
- Conducts and keeps record of the correspondence concerning preparation, signing and execution of contracts.

**GENERAL DESCRIPTION, cont.**

- Supervises preparation of the contracts of all branches of NEK exceeding 10 million leva with the exception of contracts for large-scale construction, making expert assessment of the clauses of every specific contract.
- Keeps files of direct contracts with branches of NEK exceeding 10 million leva with the exception of large scale construction contracts.
- Supervises preparation, signature and execution of commission contracts.
- The Department monitors the execution of contracts in compliance with the law and for the purpose of protecting the Company's interests.
- Works together with other departments of the Company to create the prerequisites for the best protection possible of the Company's interests.

**Labor and Salaries** - This unit is responsible for:

- Labor reporting, terminations and pensions.
- Salaries, including a quarterly analysis of actual vs. budgeted salaries paid.
- Assisting the planning departments and branches with estimated staffing needs and labor costs.
- Developing recommendations to improve labor efficiency.
- Maintaining pension and social insurance records.

Note: Each branch does its own payroll processing and sends a payroll report to the headquarters. The branches also do their own billing and collection. The data processing support for billing is provided by ENERGOPROEKT, a service firm; collections are deposited into company bank accounts.

## CURRENT STRUCTURE

The Corporate Finance Division, based in Sophia at NEK's headquarters, is composed of five units with a total staff of 28:

- Economic Forecasts and Internal Contracts
- Accounting and Financial Control
- Corporate Finance Investment Projects
- Trading and Share Holding Activities
- Labor and Salaries.

In addition, each branch has its own accounting department to handle billing and collection, payroll, and the preparation of all financial reports required of the branch.

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## KEY COORDINATING MECHANISMS

The common coordinating mechanism for an accounting function is the standardization of skills. In Bulgaria, there is a lack of trained accountants familiar with western accounting concepts and disciplines. NEK's Accounting and Financial Control unit has drawn on people with backgrounds in economics or who are otherwise numerate.

For the routine operational accounting activities, including accounts payable, billing, payroll, etc. (most of which appear to be located at the branches), the standardization of work practices is the predominant coordinating mechanism.

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## DESIGN PARAMETERS

**Work Specialization** - Most of the positions in this division require highly specialized knowledge and skill levels. For the professional staff, this includes a sophisticated knowledge of such topics as accounting principles and practices, financial statement presentation, financial and cost analysis techniques, cash management, managerial finance, etc. For the clerical staff, the knowledge set is narrower, but nonetheless significant on a relative basis in comparison to other clerical activities.

**Training and Indoctrination** - Most of the activities in the finance and accounting function require high levels of formal education and training. Even the clerical activities of this group require a significant amount of training (at a minimum) and, in certain cases, formal education.

## DESIGN PARAMETERS, cont.

**Formalization of Activities** - This is one of the most highly formalized corporate support functions. The promulgation and monitoring of accounting policies and procedures, the routine processing of accounting transactions, and the preparation of monthly and other specialized financial reports require a very high degree of formalization of activities.

**Unit Size** - Typically, a finance and accounting function for a large-scale electric utility would be moderate in size, on a relative basis. For NEK, the headquarters unit is very small — on a relative scale — and the total accounting complement (estimated at 450 for all branches combined) is a significant total, but probably still low in consideration of a high proportion of clerical staff.

**Planning and Control Systems** - The operational aspects of accounting lend themselves to standardization and classic work management techniques as adapted clerical activities. For the professional content of finance and accounting, these activities require a more sophisticated management approach. Generally speaking, the key elements include supervision by a knowledgeable professional and systems that facilitate assignment control and scheduling.

**Liaison Devices** - The professional staff require interaction with the line operating departments for budget preparation, analysis of variances, and monitoring of results, among other responsibilities. Consequently, the professional staff members of this division will require reasonably well developed liaison mechanisms with other departments. On the other hand, the operational accounting activities (now mostly located in the branches) will need little liaison with outside departments; for these groups, the standardized information inputs will satisfy most of their needs.

**Scope of Authority** - Little authority is delegated within the division. The highly defined nature of most of the work activities in finance and accounting, including a clear delineation of the scope of responsibilities, limit the need for significant delegation below the senior levels of the division.

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## OBSERVATIONS AND CONCLUSIONS

NOTE: Our review did not address the question of NEK's compliance with Bulgaria's Accountancy Act or any other applicable laws. Such issues were outside the scope of our review. Furthermore, our comments recognize that the financial and accounting systems NEK has inherited were not designed to support an enterprise operating in a market economy. Thus, our observations and recommendations are intended to emphasize improvements that will enhance the organization's ability to accomplish its mission.

**The accounting and finance function at NEK's headquarters is under-resourced relative to the division's responsibilities.** With the change from a command economy to a market-oriented economy, the accounting and financial needs of the company have changed radically. The demands of a competitive marketplace will increase dramatically for NEK. The number, skill level, and training of the current staff are already inadequate to the task at hand. This situation will grow worse with time. The allowance now given to the company in transition will soon evaporate as NEK's managers and lenders press for better financial plans, control budgets, and routine financial reports. These new demands will fall on a division that lacks both sufficient skills and the required training, and in which some of the essential processes are not yet fully developed, if they are in place at all. . This will place enormous strain on the company to carry out two major activities in parallel. Namely, these are to develop and implement basic systems and procedures at the same time the division is raising its service levels to standards consistent with its counterparts in western utilities.

**NEK's information systems are not adequate to support NEK's increased corporate planning and analysis activities.** The accounting and information systems at NEK's headquarters are resident on micro computers that are not networked. There is no on-line access to data from the company's transaction processing systems, either directly or via an information center capability. Further, the records for certain functions (e.g., personnel) are maintained manually.

Part of the problem is a holdover from the past: the company's accounting systems are rudimentary and somewhat fragmented. There is little performance measurement data and none of them is organized into a usable format such as an executive information system. The company also does not have any financial planning models.

## OBSERVATIONS AND CONCLUSIONS, cont.

These difficulties are not surprising given the magnitude of the changes NEK is going through. However, the finance function will need better information systems support to fulfill its planning responsibilities. This situation needs to be improved significantly and quickly.

**The headquarters accounting and finance function is dependent on the branch accounting departments for key financial reports.** The basic transaction processing systems of the company are controlled by the branches. Each branch is a separate legal entity with its own accounting capability. The supply branches are responsible for their own billing, collection, payables and payroll systems. The branches also prepare their own financial statements. These statements are forwarded to NEK's headquarters for use in preparing the consolidated financial statements of the company.

**The budgeting and financial planning processes are not yet fully developed.** Although both of these activities take place at NEK, both must be expanded considerably to meet the needs of the company in its new market-oriented business environment. During the course of our review, we were not given access to the company's budgets on the grounds that they were confidential. Nonetheless, our discussions with senior managers and others have led us to conclude that the budgets need to be strengthened to serve as an effective control device. Budget development does not appear to be a bottom-up process nor does there appear to be any routine variance analysis reports provided to executive or operating management. Further, NEK has not identified detailed cost centers with an individual manager or supervisor designated as responsible for each. Given these conditions, it appears that a substantial improvement in the company's budgeting process is warranted.

Likewise, the financial planning process is a new — or at least a radically changed — activity at NEK. The demands on the company's planning capability have increased dramatically with the requirement of international financing to raise capital. Even though the company's financing activity may abate for a while, this will likely be only a momentary respite. Power companies have significant capital requirements, and NEK's short- to intermediate-term capital requirements are likely to be formidable. The attendant requirements to provide updated financial information to lending institutions will continue the need for a robust financial planning process. Ultimately, however, the most compelling reason to expand this capability is that corporate management must have good financial information as the basis for corporate planning and executive decision making.

## OBSERVATIONS AND CONCLUSIONS, cont.

**The company's general accounting processes and systems are basic.** Bulgaria recently promulgated a new Accountancy Act intended to bring Bulgarian accounting practices into line with western standards. The company has made great efforts to adopt the accounting principles and practices necessary for an enterprise operating in a market economy. Nonetheless, the general accounting process must still be considered basic. The company needs to develop, redesign or acquire many of the foundation systems for an electric utility, including continuing property records, construction management, and a customer information system. NEK could also use a good general ledger system and, judging from what we have seen, a payroll/personnel system. In short, it appears that the company's general accounting systems need to be revamped or (more likely) replaced.

**The company's cash management systems are rudimentary.** Meter reading, billing and collection activities are conducted by the sales branches. A bill collector visits every residential customer once each month to read the meter and collect payment for the prior month's usage. Since most people are at work during the day, there are cash collection booths in each region. These collection booths are open four times per week (from 5 p.m. to 7 p.m. three times a week and from 10 a.m. to 12 noon once a week). The first activity in the morning is for the collectors to bring the previous day's collections into the branch office cashier. (But this is not a strict rule. If the collector has only a small amount of cash, she may wait a few days before making the deposit.) Although some residential customers (about 5 percent in Sofia) pay by bank draft, most pay in cash.

- Recently, there has been an increase in the number of assaults and thefts involving collectors. As a result, collectors will often leave a notice of payment, including late payment notices, instead of taking cash from a customer. This creates an inconvenience for the customer, but it may be unavoidable.

Almost all of NEK's commercial and industrial customers pay by bank draft. Payments are made based on an estimate for the following month's usage. Some companies pay by cash directly to the cashier in the sales branch office.

## OBSERVATIONS AND CONCLUSIONS, cont.

The sales branch controls all cash collections. All deposits are made directly to the company's bank account, with daily reports from the bank regarding subscriber payments. The headquarters sends a monthly invoice to the sales branch for the electricity sold to the branch. The branch gets an invoice for the prior month's actual amount by the 8th workday and an invoice for the following month's estimated amount on the 15th. The branch pays the estimate and the true-up; whatever cash is left is the branch's profit, to be used for its payroll and accounts payable.

**The company does not have an internal audit capability.** One of the division's new responsibilities relates to developing and promulgating financial and accounting policies and procedures, including those concerned with internal accounting controls. The success of any large organization depends on broad compliance with established corporate policies and procedures. In addition to it scale, there are several other factors that will likely lead to compliance problems, including: 1) the move from a command economy to a market-based system, 2) the transformation of NEK into profit-making enterprise, 3) the implementation of financial incentives and penalt related to performance, and 4) the implementation of many new financial policies, accounting practices, and operating procedures.

The lack of a group of trained specialists who can conduct compliance audits represents a significant control weakness. In addition to checking for compliance with financial and operational policies and procedures, an internal audit group can often identify opportunities for cost reduction or process improvement. Although expanding the scope of responsibilities to include operational auditing would likely be challenging, to say the least, it should be given serious consideration by NEK.

Generally, it is considered that the internal audit function should not report through the financial chain of command. The argument is that the audit group should not report to the function it is auditing. While we agree with the merits of this argument, we also recognize that — at least for the near future — it may be reasonable to allow this situation due to the limited skills available to perform these tasks.

## RECOMMENDATIONS

**Expand resources as necessary to continue developing a professional accounting and finance function.** The current level of staffing of NEK's Accounting and Financial Control unit is low in relation to its current, and even more so, its rapidly emerging future responsibilities. While the reasons this situation has come about are understandable, the organizational resource must be expanded and strengthened considerably as soon as possible. The division should address the following basic areas:

- Financial policies and procedures
- General accounting, including, but not limited to:
  - fixed asset accounting
  - payroll
  - accounts payable
  - accounts receivable
  - materials and supplies accounting
  - other operational accounting areas
  - general ledger.
- Financial planning and analysis, including:
  - operational control budgeting
  - variance analysis
  - capital expenditure analysis
  - long-term financial planning.
- Treasury and cash management
  - banking relationships
  - cash management
  - capital structure management
  - investor relations
- Revenue requirements and tariffs.

In addition, certain other activities should be considered for inclusion with the Accounting and Financial Control unit's responsibilities. These include internal auditing, operations analysis and performance measurement, insurance and risk management, customer billing, and information systems.

**RECOMMENDATIONS, cont.**

**Upgrade and expand basic accounting systems.** As NEK continues to adapt to the needs of operating in a market economy, it will require increasingly better accounting information. Accounting is the language of business, and effective management requires valid information. This means it must be accurate, relevant and available on a timely basis. Upgrading the company's accounting systems will be an enormous undertaking. Despite this — and perhaps because of it — management should map out a program to upgrade all of NEK's basic accounting systems, including:

- Accounts payable
- Billing and accounts receivable
- Customer information
- Continuing property records
- Construction management
- Payroll/personnel (including labor distribution)
- Materials and supplies
- General ledger.

Other sub-systems will be necessary, but the above items are the major elements of the systems NEK must implement.

**Implement basic budgeting and control concepts and information systems.** The operating control budget and the associated budget development process are among the most fundamental and effective control tools available to a large electric utility. Based on what we were told about various aspects of the company's budget and control process, it is apparent that NEK's budget process needs to be upgraded, expanded and strengthened considerably. The implementation of an improved budgeting process should be given a high priority in view of its potential impact on the results of operations.

**Establish a formal financial planning process.** Although they share some common characteristics, the financial planning process is a separate and distinct activity from the control budgeting process. The financial planning process is a new activity for NEK and, as such, will require more of a "from the ground up" development process. The most fundamental need is for a cadre of trained financial analysts to conduct the basic analytic work. Beyond this, the group will need other resources, principally computer support and — the sooner the better — some financial planning models. Ultimately, a sound financial planning process is dependent on good information. This may be difficult to obtain until NEK completes its transition to a modern uti company. In addition to these basic ingredients, the company needs two other th 1) the definition of a financial planning process and 2) training in analytic and planning activities.

**RECOMMENDATIONS, cont.**

**Implement improved cash management systems.** Bulgaria is still largely a cash economy. This limits what the company can achieve through improved meter reading, billing and collection processes. Nonetheless, there are significant potential savings available from streamlining and centralizing the management of cash. Even without waiting for the economy to advance from its cash-based system, there are certain improvements that can be considered, for example:

- Exploring the possibility of implementing a lock-box system with NEK's major bank or banks
- Making deposits directly to banks on the day cash is collected
- Encouraging customers to pay by bank draft instead of in cash
- Encouraging employees to accept payment by bank draft.

NEK can also explore other advances, such as the possibility of centralizing the management of all cash (including payables and, ultimately, payroll at the headquarters) and the use of zero-balance checking accounts. It is clear that Bulgaria's cash economy will be a constraint to many of these advances. But this could change rapidly with the economic reforms now underway. Either way, NEK should begin the improvement process now.

**Update and formalize the policy and procedure manuals for the accounting and finance function.** NEK's finance and accounting function is faced with an extraordinary range of challenges, including the need for new accounting and management information systems, the need to define key financial processes (including control budgeting and financial planning), and the need to recruit and train the staff necessary to carry out its mission. In the face of such daunting tasks, it would be easy to dismiss the need for developing and documenting policy and procedure manuals. NEK should not allow this temptation to keep it from completing these fundamental activities. The policy and procedure manuals are important defining documents for the function. They need not be elaborate, but they should be formalized.

**Establish an internal audit function.** NEK will need a strong internal audit capability, if it doesn't already have such a need. In addition to providing for oversight regarding compliance with established corporate policies and operating and accounting procedures, it can serve as a good training ground for accountants. A company's internal audit department can provide a solid indoctrination to a company's financial policies and accounting procedures. For all of these reasons, NEK should establish this function as soon as possible.

**Division Profile** | **DISTRIBUTION, SALES, AND BUSINESS ACTIVITIES (Electricity Supply Branches)** | **Exhibit 2-**

## GENERAL DESCRIPTION

The Distribution, Sales and Business Activities Division encompasses all activities involved in the delivery of energy to customers, from the point of dispatch to the customer's premises. Because our work included a separate review of central dispatch, we focus here on the electricity supply branches.

The electricity supply branches are responsible for customer-related and field activities, including meter reading, billing, collection, meter installation and repair, and operations and maintenance work related to the transmission and distribution system. Each electricity supply branch is a separate legal entity with its own support staff including accounting, legal and administration.

In January 1992, NEK instituted the existing network of 28 electricity supply branches. In the late 1960s, the company went from 13 branches (12 "country" branches plus Sofia) to 7 (6 "country" branches plus Sofia). This structure remained in place until 1992. With the inauguration of the National Electric Company, the network of branches was increased to 28. This was accomplished by declaring certain satellite offices to be separate branches. The 28 branches coincide with the provinces in Bulgaria.

The headquarters function for the electricity supply branches includes a staff of 13. This is a policy making, standard setting, and technical advisory group with dotted line reporting by the electricity supply branches.

## CURRENT STRUCTURE

The division is organized into three units:

- Central Dispatch Control
- Electricity Supply
- Electricity Import and Export.

## CURRENT STRUCTURE, cont.

The headquarters function for electricity supply consists of three sections:

- Research, which is responsible for researching the electric transmission and distribution system. Requests for line construction must be approved here; any request up to 4,000 kW can be approved by one of the branches. Requests above 4,000 kW must be submitted to the headquarters.

- Maintenance, which establishes work methods, develops the annual schedule of work, and provides the technical assessment of major items of equipment.

- Sales, where the primary focus is on assisting in the preparation of purchase and sales contracts.

The electricity supply branches are separate legal entities with their own accounting and administrative support capabilities. Using the Sofia branch as an example, the large electricity supply branches are organized as shown in Exhibit 2-1. The principal organizational units include:

- Dispatch operations
- Maintenance and repairs
- Research and development
- Distribution and sales
- Materials and supplies
- Field operations. This group has six units reporting to it, including:
  - Four regions (North, South, East and West)
  - Substations
  - A group responsible for major repairs.
- Finance and accounting
- Legal
- Labor improvement
- Salaries and planning
- Training
- Administrative support.

## KEY COORDINATING MECHANISMS

For the activities involving central dispatch and import/export, the key coordinating mechanisms are standardization of skills and standardization of work processes.

For the electricity supply branches, the range of activities involves a variety of coordinating mechanisms, including direct supervision, standardization of skills, and standardization of work processes.

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## DESIGN PARAMETERS

**Work Specialization** - Most of the activities in the electricity supply branches are highly specialized.

**Training and Indoctrination** - In general, these are activities that require and/or benefit from significant training (skills training as well as supervisory training).

**Formalization of Activities** - Typically, significant time and effort are spent formalizing as many of these work activities as possible.

**Unit Size** - Relatively large.

**Planning and Control Systems** - These activities benefit from formal planning and control mechanisms. Some of the most common mechanisms that are suitable for these types of activities include accounting control budgets, work force management systems, meter reading routing and scheduling, formalized work planning, and management systems and formal project management systems.

**Liaison Devices** - Liaison with other units is mostly confined within each branch. Simple liaison mechanisms are adequate for the inter-departmental and inter-branch communications needed.

**Scope of Authority** - Decision making and lines of authority are clearly defined, but the delegation of authority is limited. There is some horizontal decentralization of decision making, but there is little vertical decentralization in decision making authority.

## OBSERVATIONS AND CONCLUSIONS

**Many of the smaller new branches are under-resourced.** When NEK went to a network of 28 electricity supply branches, there was apparently not a companion effort to ensure that every branch had resources consistent with their needs. Some of the "new" branches were formerly satellite offices of the larger branches. As such, they did not need to have a full complement of testing and other equipment. Since the creation of these branches, there has been a disproportionate increase in the number of calls for assistance from the small branches. These branches formerly relied on the host branch for assistance; now they look to the headquarters, which is not equipped to provide a significant level of help.

**Transmission line losses are not separated out from distribution losses in judging branch performance.** Transmission line losses are intermingled with distribution losses under the company's reporting systems. This makes it difficult to impossible to identify the causes of losses and assign responsibility for them. This situation, in turn, impedes the initiation of any corrective action.

## RECOMMENDATIONS

**Consolidate the 28 existing branches into a smaller number of larger branches.** It is clear that there are too many branches under the current configuration. The smallest of the branches appear to be seriously under-resourced and, perhaps under-managed. NEK should reassess this situation to target a reduction in the number of branches to an optimum level. Without benefit of a detailed study, our expectation is that such a reassessment will determine that the optimum level is in the range of ten to fifteen branches.

**Initiate a program to increase the company's control of meters.** The current situation surrounding the company's ability to gain access to meters and to test and repair faulty meters will only get worse if left unaddressed. As the price of electricity rises, customers will have a greater incentive to prevent the company from repairing slow meters. And at any price, the company is not being paid for all the electricity being consumed under a system that could be riddled with defective meters.

**Use caution in evaluating the acquisition of advanced meter reading technology.** The advanced meter reading technologies now available offer substantial potential benefits to the company. However, our concern is that — even with compelling benefits — they may not be economically justifiable for NEK at this time.

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## OBSERVATIONS AND CONCLUSIONS

**Many of the smaller new branches are under-resourced.** When NEK went to a network of 28 electricity supply branches, there was apparently not a companion effort to ensure that every branch had resources consistent with their needs. Some o the "new" branches were formerly satellite offices of the larger branches. As such, they did not need to have a full complement of testing and other equipment. Since the creation of these branches, there has been a disproportionate increase in the number of calls for assistance from the small branches. These branches formerly relied on the host branch for assistance; now they look to the headquarters, which is not equipped to provide a significant level of help.

**Transmission line losses are not separated out from distribution losses in judging branch performance.** Transmission line losses are intermingled with distribution losses under the company's reporting systems. This makes it difficult to impossible tc identify the causes of losses and assign responsibility for them. This situation, in turn impedes the initiation of any corrective action.

## RECOMMENDATIONS

**Consolidate the 28 existing branches into a smaller number of larger branches.** It is clear that there are too many branches under the current configuration. The smalles of the branches appear to be seriously under-resourced and, perhaps under-managed NEK should reassess this situation to target a reduction in the number of branches tc an optimum level. Without benefit of a detailed study, our expectation is that such a reassessment will determine that the optimum level is in the range of ten to fifteen branches.

**Initiate a program to increase the company's control of meters.** The current situatio surrounding the company's ability to gain access to meters and to test and repair faulty meters will only get worse if left unaddressed. As the price of electricity rises, customers will have a greater incentive to prevent the company from repairing slow meters. And at any price, the company is not being paid for all the electricity being consumed under a system that could be riddled with defective meters.

**Use caution in evaluating the acquisition of advanced meter reading technology.** The advanced meter reading technologies now available offer substantial potential benefit to the company. However, our concern is that — even with compelling benefits — they may not be economically justifiable for NEK at this time.

**RECOMMENDATIONS, cont.**

This danger is greatest with the fully automated technology that relies on the telephone system for polling meters. These systems require the installation of a device on the customer's meter; this instrumentation is costly (ranging from US$ 50 to US$ 150, without installation). The one-time costs of these systems constrain most western utilities from justifying them in terms of cost savings — and the cost of meter readers is typically many times higher than in Bulgaria. When added to the likely difficulties associated with using the local telephone system, the prospect of successfully implementing this technology becomes highly problematic.

The situation with the hand-held systems is less clear, but it should likewise be approached with caution. A reduction in meter reading errors is clearly a desirable result, but these systems can be costly too. Given these conditions and NEK's low labor costs, the company may get a better return from a program to increase the accuracy of installed meters.

**Separate the reporting of transmission losses from distribution losses.** A prerequisite for a successful effort to reduce line losses is the clear separation of electricity losses by cause. Once this is done, the appropriate responsibility can be assigned and corrective action initiated. We understand that the company recently examined the possibility of accomplishing this recommendation. The company's study looked at the substations and the types and quality of meters that would need to be installed. The study concluded that the program would require two years to complete and would cost about 50 million leva (about two million U.S. dollars).

## GENERAL DESCRIPTION

The Development and Investment Division consists of two departments: Analysis and Development, and Investment. Analysis and Development has two responsibility areas.

- Energy or Corporate Planning - This includes planning programs for consumption, forecast for loads and operation/optimization of functions. All of these activities are to be conducted using least-cost methods.

- Research - The department conducts research related to forecasting the need for additional generating capacity. This includes research into the demand for all forms of energy, including oil, gas, propane, briquette, coking coal, etc. The actual demand and load forecasts are prepared either by the division or by an outside group.

- Forecasting and optimization of generation capacity is only a part of the total energy and fuel sector. This division develops detailed forecasts of electricity demand related to the macro-economic conditions of the country.

- The models used by the division are copyrighted and maintained within the unit.

- The unit also conducts research into all types of plants, including thermal, hydro and nuclear, as well as research into the transmission network.

Some examples of research projects currently underway include:

- General problems, such as studies regarding the energy balance for the population of Bulgaria

- Gasification of households, including its impact on NEK's business

- The use of electricity for lighting (efficiency)

- Environmental effects of power stations.

## DESIGN PARAMETERS

**Work Specialization** - The work activities here are highly specialized and, generally speaking, require professional-level training.

**Training and Indoctrination** - Most of the work in these areas requires a university degree and, for certain responsibilities, an advanced degree. A certain amount of training is necessary to impart the industry-specific and company-specific knowledge requirements, but these requirements are readily imparted to a candidate with the appropriate educational qualifications.

**Formalization of Activities** - Although these activities adhere to established approaches and techniques, etc., they require methodological planning and technical analysis that requires that this work be classified as unstructured.

**Unit Size** - Very small.

**Planning and Control Systems** - There is little need for formal planning and control systems beyond the basic scheduling, assignment control, and calendar control systems typical of professional work activities.

**Liaison Devices** - Not relevant. Limited liaison is required; most communications from this division take place through formal channels.

**Scope of Authority** - Not relevant.

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## OBSERVATIONS AND CONCLUSIONS

**The work performed by this group combines elements of system planning and capital expenditure analysis.** Some of the major areas of responsibility for this group relate to demand forecasting and capacity planning. Another set of activities is related to capital expenditure analysis to assess the economic viability of a proposed project. The skills necessary to perform this work should be applicable to corporate planning and/or financial analysis.

## GENERAL DESCRIPTION, cont.

Once a specific need is identified, the Investment Department investigates the investment that will be required. For example, some recent problems include the rehabilitation of the existing plants and the automation of the production process, including the automation of the dispatch function. At present, the highest-priority investments fall into three areas:

- Nuclear investments to improve the safety and reliability of Kozloduy
- Rehabilitation of existing thermal plants
- Completion of the Chaira pumped storage plant.

The critical steps for the Research and Development unit are to:

- Develop a sound capacity expansion plan for the next ten years
- Establish prices that will enable NEK to operate profitably.

The critical steps for the Investment unit are to:

- Complete the low-level radwaste and spent fuel facilities
- Complete the pumped storage hydro plant.

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## CURRENT STRUCTURE

The division is organized into two departments:

- Analysis and Development, with a staff of six
- Investment, with a staff of ten.

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## KEY COORDINATING MECHANISMS

In this division, the key coordinating mechanisms are the standardization of skills and direct supervision.

## OBSERVATIONS AND CONCLUSIONS, cont.

Specific training will be required to master the skills required to conduct expanded least-cost-planning (LCP) activities. The company expects to be able to accomplish this through a variety of means, including assistance from other power companies, e.g. Central Maine Power Company and Electricite de France. However, the department considers that three other elements are key to its ability to accomplish the requirements of least-cost-planning. They include the right number and mix of skills among their staff, LCP software and the creation of the appropriate data bases of energy statistics.

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## RECOMMENDATIONS

**Explore the possibility of consolidating the Investment Department as part of the newly formed finance function.** The skills required for both departments are similar or overlapping. Given the close relationship between many of the work activities of the two groups, NEK should consider consolidating them.

## GENERAL DESCRIPTION

The Generation Division includes all of NEK's power production activities. The responsibilities of the division's headquarters staff are:

- Thermal and Hydro - includes repair specialists who are familiar with the technical and economic characteristics of the plant.
  - This group must approve all requests for maintenance work
  - All plant proposals are submitted to headquarters
  - This unit maintains close ties to the Operations and Fire Protection group
  - It also attends all division meetings.

- Nuclear - coordinates documentation with safety authorities, coordinates repair work, and is responsible for nuclear fuel supply for the Kozloduy nuclear station and its 5,000 employees.

  - Due to the small size of the staff, there is no strict specialization of skills.

  - There is one chief specialist responsible for the operation of all steam generators, a second responsible for all electrical equipment, a third responsible for all automated systems, and a fourth who is a chemist focusing on water/chemical treatment and radio chemistry at the plant.

  - Another is responsible for worker safety; he deals with all modernization and reconstruction activities.

  - Another prepares all maintenance and repair schedules and works with the central dispatching group to develop a comprehensive maintenance schedule.

  - The unit also participates in the contract negotiations for any work to be done by an outside contractor.

  - It also provides technical advice to the plant, and coordinates the work of evaluation teams conducting periodic audits.

  - This unit also follows the developments of various international nuclear bodies, and prepares information responses as necessary.

**GENERAL DESCRIPTION, cont.**

- Operation Procedure Compliance and Safe Practices - is responsible for analyzing failures, including all accidents in the energy system, and is responsible for coordinating with the other departments (e.g., thermal production) and the Home Ministry. The prevention of failures, including the promulgation of control procedures, is a key responsibility of this unit. Its major functions and responsibilities are as follows:
  - Oversees compliance with the technical operating procedures (TOP) for power plants and networks, electrical installation layout procedures (EILP), approved regulations for nuclear operations, fire protection, requirements of the State Inspectorate of Technical Supervision, and with other operation and maintenance related normative documents on the part of power generation and distribution branches of the Company.
  - Investigates or participates in the investigation of accidents occurring at the branches and enterprises of NEK.
  - Develops and follows up accident prevention actions.
  - Conducts or participates in problem-oriented inspections for operation safety and efficiency improvements at the branches and enterprises of the Company.
  - Draws up and distributes among the branches and enterprises of the Company technical briefs about major events which have occurred and the corrective actions to be taken with respect to such events.
  - Directly participates in, and manages implementation of all orders and other instructions of the Company's management concerning power plant and network operation procedures, fire protection and industrial safety.
  - Keeps record of infringements on the normal practices of the Company's branches and enterprises, as well as of the related performance indicators and labor accidents. On the basis of information received and of accident investigation results, prepares, on a regular basis, analytical information for the Managing Board with power plant and network operation reliability assessments, and proposals aiming at reliability improvements.

**GENERAL DESCRIPTION, cont.**

- Maintains regular contacts with and methodological control over the operating safety, industrial safety and fire protection managers at the branches and enterprises with a view to obtaining up-to-date information, its clarification and follow-up of the safety upgrading measures in the power plants and networks of the Company.

- Participates directly in the development of instructions and other procedures related to the routine operation of power plants and networks.

- Attends the engineering boards and gives opinion about the procedure compliance level and work safety at discussions on power projects.

- The department implements its functions by maintaining contacts as listed below:

  — At the Committee of Energy with the sections in charge of operations and work safety

  — With the Committee for Peaceful Uses of Atomic Energy in relation to nuclear operations supervision at NPP Kozloduy

  — At the Ministry of Home Affairs with the section in charge of power site fire protection

  — With the State Inspectorate of Technical Supervision on matters of pressure vessel monitoring.

- The order of execution of the Department's functions is determined by existing normative documents on power plant and network operation and fire protection.

- The work of the Operation Procedure Compliance and Work Safety Engineering Staff at NEK's branches is organized as follows:

  - The engineering staff responsible for operation procedure compliance and work safety is appointed at the positions allocated to the respective branches and reports directly to the branch or enterprise manager.

**GENERAL DESCRIPTION, cont.**

- Responsibilities of the operation procedure engineering staff:
  - preventive measure control for assuring compliance with the prevailing rules and facility operation procedures
  - development and follow up of actions aiming at facility operating reliability
  - investigation of failures and infringements in the facility's operation, compilation of materials and analysis of facts, as well as ranking of failures and infringements
  - preparation and submission of reports in compliance with prevailing instructions.
- Responsibilities of the work safety engineering staff:
  - preventive measure control for assuring compliance with prevailing rules and work safety procedures for O&M staff
  - development and follow up of actions aiming at work safety improvement
  - investigation into employment accidents
  - preparation and submission of reports on employment accidents recorded at the branch or enterprise in compliance with existing instructions.
- The functions of operating procedure compliance and work safety may be executed by the same person.
- Every month the operating procedures and work safety engineering staff submit proposals for staff remuneration in compliance with the internal salary management rules and depending on operation and work safety compliance level.

**GENERAL DESCRIPTION, cont.**

- The new structure of NEK provides for an increase in the number of engineering specialists at the head office, direct subordination of the control unit to the President of the Managing Board, and expansion of the unit's function scope by:
  - Monitoring of compliance with nuclear safety regulations at NPP Kozloduy
  - Monitoring and control of operating and industrial safety activity at the branches and enterprises
  - Development of proposals for amendment of management and executive staff salaries depending on the reliability and safety of the respective facility operation.
- Special Means of Transport - is responsible for all supplies that are centrally contracted, including all common spare parts (which are contracted out). Any spares that are plant-specific are bought by the plants themselves. This unit is also responsible for consigned stocks, which are maintained on a centralized basis. It also handles all fuel oil contracts.
  - All other contracts are handled by the plants themselves.
  - An estimate of the volume of central vs. plant purchases is that the centralized spares contracts totalled about 200 million leva, while the plants contracted for about 400 million to 500 million leva.

The Thermal/Hydro and Nuclear production headquarters staff participate in the budgeting process for the Generation Division by proposing the budget for repairs and working with the experts who develop the planned capital investments. These units also review all expenses as well as all maintenance and repair-type capital expenditures.

- The Development and Investment Department is responsible for all new projects.

## CURRENT STRUCTURE

The division is organized into four units:

- Generation: Thermal, Hydro and Nuclear, with a staff of nine
- Generation: Nuclear Power Plants, with a staff of five
- Operation Procedure Compliance and Safe Practices, with a staff of 65, three of whom are located at the headquarters.
- Special Means of Transport, with a staff of eight.

Each of the power plants is a separate organizational unit, although not a separate legal entity, with significant decision making authority. The plants can negotiate and sign all types of contracts, including:

- Fuel
- Repairs
- Research and Development
- Spare parts
- Loans up to 100 million leva
- Any transaction for fixed assets under 50,000 leva.

However, the plants cannot make any foreign trade agreements, and any investment loans must be authorized by headquarters. Otherwise, the plants have fairly broad decision-making authority to run their businesses.

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## KEY COORDINATING MECHANISMS

The key coordinating mechanism for production activities is the standardization of work activities.

## DESIGN PARAMETERS

**Work Specialization** - The work activities at the power plants are highly structured and specialized. Most of the managerial, professional, and technical positions require university degrees, usually in an engineering or technical discipline. Many of the plant operator positions, including those involved in maintenance and repair activities, require significant skills that typically are learned through technical courses, apprenticeship and journeyman programs, and on-the-job experience.

**Training and Indoctrination** - These operations generally require or otherwise warrant significant training and development programs.

**Formalization of Activities** - Most of these activities are highly formalized and proceduralized. This is particularly true of the nuclear plant activities.

**Unit Size** - The plants have very large staffing complements (e.g., 5,000 at Kozloduy and 1,000 at Bobov Dol), but headquarters is very small, both in absolute and relative terms.

**Planning and Control Systems** - The activities required to manage power generation operations effectively require complex, sophisticated, and formalized planning and control systems.

**Liaison Devices** - Liaison is an important activities with three groups: labor syndicates, fuel suppliers, and independent contractors (for repair and maintenance activities, etc.).

**Scope of Authority** - Broad discretion and decision-making authority have been delegated to the plants. This is consistent with the relationship between NEK's headquarters and the electricity supply branches, although it allows considerably more decision making authority than is customary in the west.

**Department Profile** | **ADMINISTRATIVE AND PUBLIC SERVICES** | **Exhibit 2-6**

## GENERAL DESCRIPTION

The Administrative and Public Services Department is responsible for a range of support services, including:

- Administrative services including secretarial and word processing staffs, mail, computer services, telecommunications, fax and copying machines.
- Information safety (records retention, etc.) regarding corporate documents.
- Transportation services including arrangements for visitors and involving company cars and microbusses. This area also involves responsibility for maintenance of the elevators.
- Deliveries within the company (furniture, supplies, etc.).
- Management of the company resorts. The company owns three resorts on the Black Sea and five smaller resorts in the mountains for the use of employees.

## CURRENT STRUCTURE

The department has a staff of 25, excluding contract workers (e.g., cafeteria, janitorial) organized by major function. Most of these employees hold clerical-level positions.

## KEY COORDINATING MECHANISMS

Direct supervision.

## DESIGN PARAMETERS

**Work Specialization** - Most of these positions are unskilled (e.g., drivers, copy machine operators), although certain of them (e.g., secretaries, word processing operators) are arguably semi-skilled.

## DESIGN PARAMETERS, cont.

**Training and Indoctrination** - Generally, these positions do not require extensive training or indoctrination. Some limited skills training is required for certain positions. Most involve on-the-job training.

**Formalization of Activities** - There is some formalization of work activities for certain positions, but overall, there is little compared to other functions.

**Unit Size** - Small.

**Planning and Control Systems** - The nature of the work activities requires only the more rudimentary scheduling and work planning and control systems.

**Liaison Devices** - Not relevant.

**Scope of Authority** - Little to none.

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## OBSERVATIONS AND CONCLUSIONS

None.

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## RECOMMENDATIONS

**Consider consolidating this function under a vice president of administration.** See the discussion presented in Exhibit 2-7, Foreign Relations and Protocol Department.

# FOREIGN RELATIONS AND PROTOCOL



## GENERAL DESCRIPTION

The Foreign Relations and Protocol Department is responsible for the coordination and control of all the international activities of NEK. Any activity involving any entity outside Bulgaria must go through the Foreign Relations and Protocol Department. The department's responsibilities include:

- Participation in policy development matters involving foreign relations
- Coordination and control of relations with foreign partners and international organizations
- Coordination and control of the activities of any member of the organization participating in the activities of any international organization
- Coordination of symposia and exhibitions to study foreign scientific or technical matters or any activity involving the exchange of technical knowledge
- Implementation of the Bulgarian Secretariat in various countries
- Coordination of separate units within NEK for investment, design, construction and operations involving any international element
- Maintenance of an information system for the foreign relations of NEK
- Coordination of and participation in the implementation of any document, rule making, or agreement signed by state bodies regarding electric energy
- Coordination of aid from foreign governments regarding loans from foreign banks
- Translation from Bulgarian to another language (and vice versa) of correspondence or documents with foreign partners
- Control and preparation of all documents authorizing foreign travel
- Implementation of all protocol services.

## CURRENT STRUCTURE

The department has a staff of ten people organized as follows:

- Coordinators for
  - Nuclear
  - Power Generation
  - Distribution and Supply of Electricity
- Interpreters and translators, with language capabilities in English, French, German and Russian
- Service protocols, responsible for booking travel arrangements, obtaining visas and other necessary travel documents.

## KEY COORDINATING MECHANISMS

The department has mostly direct supervision by trained experts with responsibility for monitoring and control over the activities of other departments with foreign relations aspects. It has standardization of skills for translation services and standardization of work practices for protocol services (i.e., travel-related documentation).

## DESIGN PARAMETERS

**Work Specialization** - The general monitoring and oversight of other departments requires a relatively sophisticated knowledge of NEK's business, with an understanding of international travel, protocols, etc. requires a combination of experience and specialized training (e.g., nuclear). The level of dealings within NEK requires that this position be headed by a highly educated person. The translation services require highly specialized skills, while travel arrangements require specialized knowledge gained mostly on the job.

## DESIGN PARAMETERS, cont.

**Training and Indoctrination** - The preparation for translation services requires significant formal education. The travel-related documentation and arrangements would require limited skills training, probably on-the-job training. The high-level monitoring of other departments' activities would appear to require mostly a certain intellectual ability rather than specific skill training (i.e., training beyond the university level required to deal with department heads).

**Formalization of Activities** - Much formalization is required to support this function, in the form of reports, notifications of intent, etc.

**Unit Size** - Very small relative to the size of the overall organization.

**Planning and Control Systems** - The department's emphasis is on controlling the actions and outputs of other departments. This entails an information system geared to monitor outside events (symposia, trades shows, etc.) as well as internal activities (e.g., equipment purchases from a foreign vendor).

**Liaison Devices** - This department is dependent on others to provide it with the information necessary to accomplish its mission. It should thus have well-developed liaison devices in place.

**Scope of Authority** - There is limited authority delegated within the department (the department head exercises most decision-making authority).

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## OBSERVATIONS AND CONCLUSIONS

**The Foreign Relations Department may represent a managerial resource that can be used to create organizational leverage.** The department may offer the potential for some managerial leverage. The nature of the activities of this department have provided it with a broad overview of the entire NEK organization and unique involvement in its external dealings. This may represent a core of expertise that can be built on or used to consolidate other activities.

**Department Profile** **LEGAL DEPARTMENT** **Exhibit 2-8**

## GENERAL DESCRIPTION

The Legal Department is responsible for all legal matters, including representing NEK in the courts. The department checks trading documents as required by other departments and branches. Each branch is required by Bulgarian law to have its own attorney; consequently, many documents are developed by the branches but approved by the headquarters legal staff.

The company makes little use of outside attorneys. The exception to this is in the negotiation of loan contracts with foreign banks. These require the opinion of an independent lawyer. Typically, a lawyer is proposed by the company, but he or she must be approved by the bank(s).

## CURRENT STRUCTURE

There are three attorneys in the department, one of whom is the department manager. Each branch has its own attorney, adding another 42 lawyers to the total.

## KEY COORDINATING MECHANISMS

The standardization of skills is the principal coordinating mechanism in a professional service organization. This is augmented by direct supervision in this small department.

## DESIGN PARAMETERS

**Work Specialization** - The work of this department is highly specialized; a law degree is required to carry out the professional aspects of the department's responsibilities.

**Training and Indoctrination** - Little training or indoctrination is needed for this department because of the stringent educational requirements for attorneys.

**Formalization of Activities** - There is little formalization of work practices for a professional work unit. There is, however, a certain degree of formalization inherent in the application of the procedural requirements of Bulgarian laws and regulatic

**Unit Size** - Very small on an absolute and a relative basis.

## DESIGN PARAMETERS, cont.

**Planning and Control Systems** - Little formal planning and control is required for this department because of the well defined and legally prescribed nature of the work.

**Liaison Devices** - Little liaison is conducted with other departments, except in procedurally defined situations.

**Scope of Authority** - Not relevant because of the small size and professional nature of the department's work.

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## OBSERVATIONS AND CONCLUSIONS

**The company's lawyers are distributed throughout the organization.** According to Bulgarian law, each legal entity must have its own legal advisor. This has led to a situation where there are attorneys at each of NEK's branches. It is unlikely that this allows for the optimal use of this resource.

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## RECOMMENDATIONS

**Explore the possibility of consolidating more of the attorneys at the headquarters.** If the company could consolidate more of the attorneys at its headquarters location, it would enhance its ability to optimize the use of this highly-skilled resource. The department would probably be able to handle more work without an increase in staffing. Such a consolidation would also increase the flexibility of the department and allow for some specialization of skills.

Clearly, any such action would have to comply with Bulgarian law. However, it may be that each legal entity can have its own attorney, but located at the headquarters in Sofia rather than at the branch. There may also be instances where it is advisable to maintain lawyers at certain branch locations. Partial consolidation on a regional basis is another option that might be a viable alternative; it might also be done in conjunction with a concentration of more attorneys at the headquarters.

We recognize that there are some practical difficulties associated with this recommendation. One relates to the time and cost of moving documents among the branches and the headquarters. As Bulgaria's telecommunications and parcel delivery services improve, this problem will be significantly diminished. There are other obstacles, but these must be tackled one by one. If they are, we believe NEK will be able to obtain beneficial results.

**Department Profile** **OFFICE OF THE PRESIDENT** **Exhibit 2-9**

## GENERAL DESCRIPTION

This department has the following areas of responsibility:

- Preparing any required materials for meetings of the Managing Board or the Supervisory Board
- Monitoring the decisions and orders of the Supervisory Board
  - Because the departments (as opposed to divisions) are not represented on the Managing Board, the Office of the President is responsible to convey to them any required orders.
- Public relations, including maintaining contacts with the media
- Maintaining contact with the labor syndicates.

An additional person (an attorney) has been added to the department to handle all types of formal requests that come into NEK. These include requests from the general public and firms for new hook-ups, general inquiries from the public, and labor disputes at any of the branches, among others.

## CURRENT STRUCTURE

The department consists of three positions, two of which were filled at the time of our review.

## KEY COORDINATING MECHANISMS

Direct supervision.

## DESIGN PARAMETERS

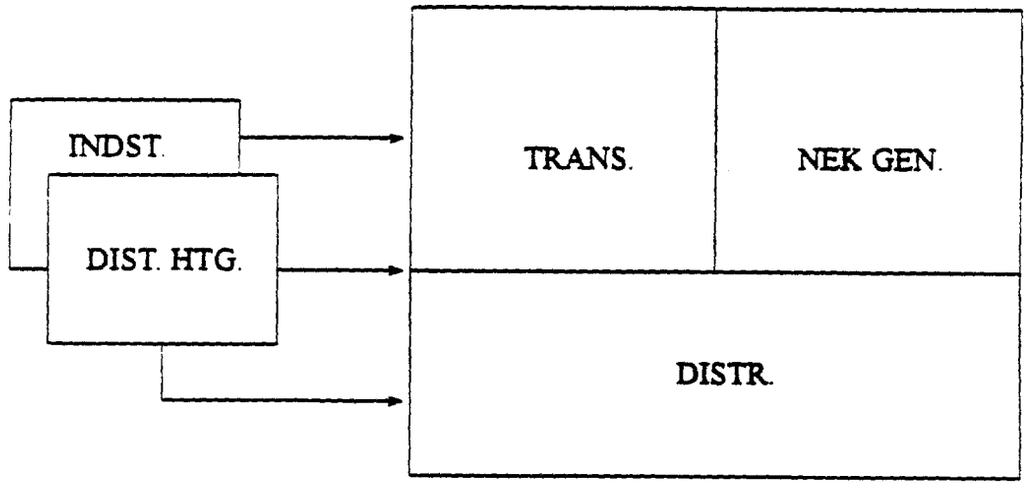
**Work Specialization** - The work in this area may be administratively complex, but it is not highly specialized.

## RECOMMENDATIONS

**Consider consolidating the responsibilities of this department under a vice president of administration.** The activities of this department are such that they would be easier to accomplish if they could be spread out over a larger group. This is particularly true of those occasions when multiple work peaks or deadlines coincide. Given this consideration and the fact that there appears to be some similarity among several of the corporate staff departments at NEK, the company should explore the feasibility of combining these departments under a vice president of administration.

**Develop and implement an automated executive information system to facilitate the monitoring of key orders of the Supervisory and Managing Boards.** The monitoring of Board decisions will likely always require a certain amount of ad hoc follow up. However, it might also be useful if the company developed an executive information system to provide senior management with performance indicators and other information — such as the status of Board decisions — without having to make specific inquiries.

# Exhibit 4-2 (a)
# Bulgarian Electricity Sector
# Structural Change Implementation Process




The current arrangements with non-NEK suppliers of energy, such as district heating sources and NEK's customers who have the capability to produce and are doing so, must be formalized to estblish commitments, incentives and penalties, ensure quality, and set compensation.

Prerequisites and Actions:

1. Evaluate adequacy of Bulgarian commercial statutes and practices to support formal power purchase arrangements with existing suppliers (e.g., district heating and industrial customers).

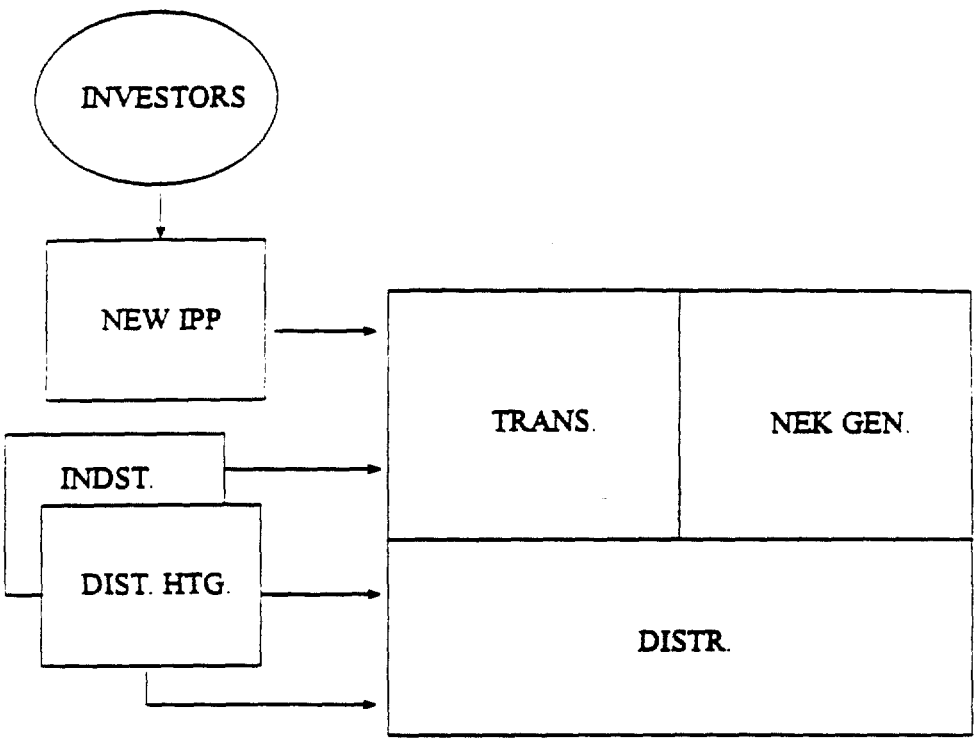
2. Pursue any necessary changes to Bulgarian legal framework which are needed to ensure viable business arrangements.

3. Build up NEK capability to establish, negotiate and manage power purchase arrangements.

4. Develop a model power purchase agreement.

5. Pursue and execute formal arrangements with existing suppliers.

# Exhibit 4-2 (b)
## Bulgarian Electricity Sector
## Structural Change Implementation Process




Cost effective new sources of energy and capacity can be introduced by creating an environment which facilitates development of independently owned generators providing power to the NEK system under contracts. A demonstration project should be undertaken.

Prerequisites and Actions:

1. See First Step, evaluate legal framework for support of business enterprise, contracts, bidding procedures; pursue improvements which enable development of independent power resources.

2. See First Step (3), develop NEK capability to solicit, evaluate, negotiate, and execute IPP agreements.

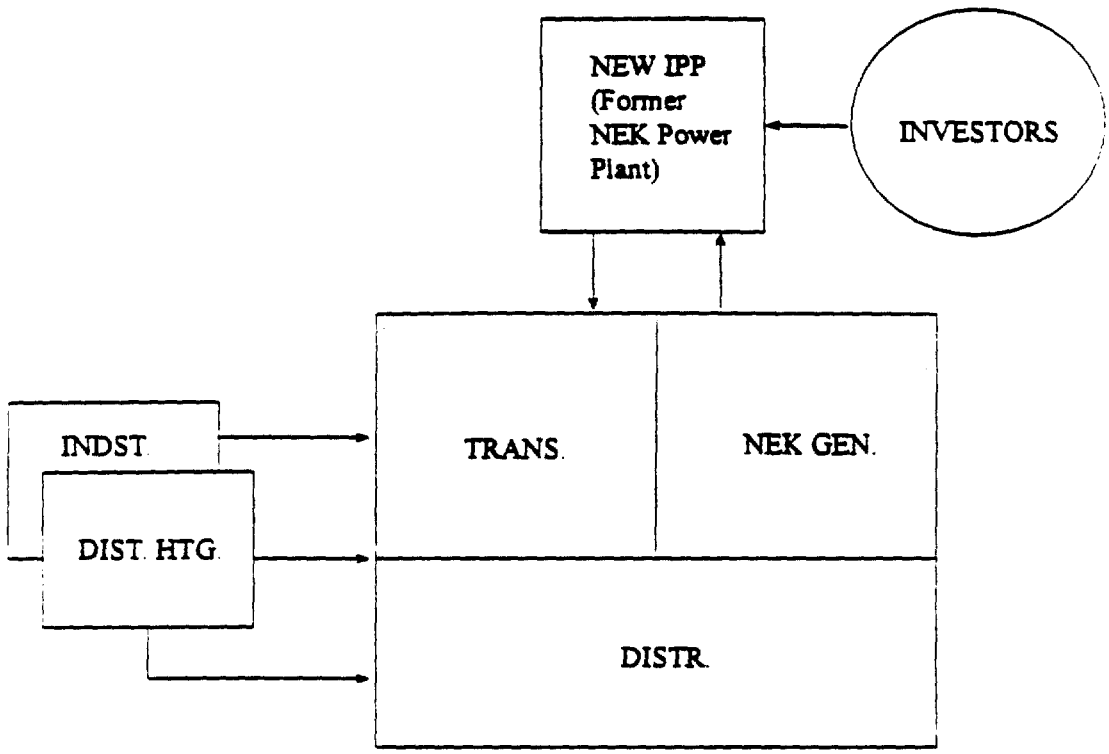
3. Identify model project opportunity; execute agreement; evaluate process and results.

4. Prepare integrated resource plan; use to guide nature and amount of sourcing needs and opportunities.

5. Prepare tenders for resources needed.

6. Evaluate proposals, select; negotiate contracts.

# Exhibit 4-2 (c)
# Bulgarian Electricity Sector
# Structural Change Implementation Process

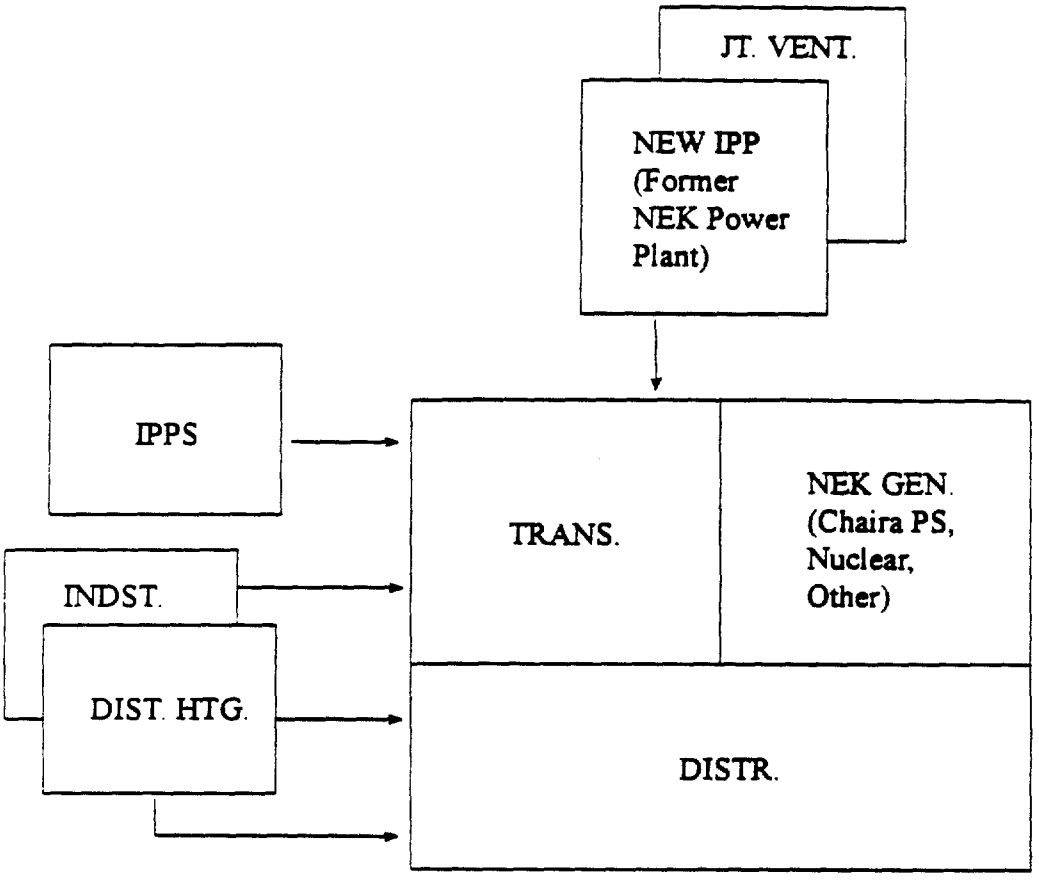



Certain generating assets of NEK could potentially be sold to third party(ies) to improve the efficiency of the sector. For example, capital attraction for rehabilitation or reduction of NEK's exposure to cost risks from operations, are possible reasons to divest.

Prerequisites and Actions:

1. See items 1-4 in "new IPPs" step.
2. Select the best first plant for divestiture as guided by the resource plan.
3. One or more interested investors must be available.
4. Prepare tender, evaluate proposals, negotiate terms.
5. Prepare necessary documents for sale and contract for delivery of power to NEK grid.
6. Explore options for NEK-third party joint venture arrangement.

# Exhibit 4-2 (d)
## Bulgarian Electricity Sector
## Structural Change Implementation Process




Based on the experience gained and results obtained, evaluate opportunities for continuing operational efficiencies or financial benefits from organizational reforms in the generating sector.

# 5.0 REGULATION OF THE ELECTRIC POWER SECTOR IN BULGARIA

## 5.1 OUTLINE OF THIS CHAPTER OF THE REPORT

This chapter is organized as follows: sections 5.2 through 5.4 below describe the current structure of regulation of the energy industries in Bulgaria. Section 5.5 discusses regulation during the transition period and describes the new draft legislation for regulation of the electric power industry.

## 5.2 ENVIRONMENTAL REGULATION

Protection of the environment in Bulgaria, apart from nuclear generation, is primarily the responsibility of the Ministry of Environment. The work of that agency in monitoring and regulating the electric power sector is described in Appendix C1. Standards have been developed and regulations promulgated relating to air and water pollution. Essentially, environmental protection is carried on in a command-and-control mode, much as it was (and to a considerable extent still is) in the United States prior to the recent passage of the Amendments to the Clean Air Act (CAA).

It is recognized that, at least through 1995, many electric power facilities in Bulgaria will be unable to meet the established standards without substantial infusions of capital. Consequently, exceptions and compromises will be necessary for some time. Nevertheless, efforts are in progress to accomplish as much as possible within existing limitations.

The standards that have been developed for Bulgaria appear to be based primarily on standards developed elsewhere, rather than on any overall set of objectives for air and water purity for the country of the type employed in the CAA. Bulgaria's size and geographic location is such that standards may not be meaningful unless developed and enforced on a multi-national basis.

Whether or not standards are based on national or multi-national pollution control objectives, it is important that some method be employed to ensure that such standards are met efficiently. In the United States, a market mechanism is being employed for this purpose. Of over 100 U.S. power plants, each has been assigned a specific number of pollution allowances, each of which constitutes a right to generate a specified amount of $SO_2$ per year after 1995. Generation by any utility of $SO_2$ beyond the amount for which it has allowances carries stiff penalties. A utility may choose any of several methods to comply with its allowance limits, such as installation of one or more scrubbers, purchase of low-sulfur coal or generation with fuels containing less $SO_2$, such as natural gas. Alternatively, it may choose to purchase allowances from other utilities that have excess

maintain an average margin of about 1.5 percent. Many of the branches, however, operate at a loss. The incentive mechanism currently in place for the sales branches is not based on profit margins but on transmission and distribution losses.

Prices charged by a privatized NEK to its sales branches, if these were independent companies (affiliated or unaffiliated with the NEK), should be regulated by an independent agency or commission. Prices charged by distributors should be set on the basis of those purchased power costs plus distribution costs. In Bulgaria, the need for regulation of transfer prices will depend on the form and the extent of the industry's disaggregation. If the form of disaggregation is limited to establishing profit centers, there will be a need for carefully designed transfer prices to encourage goal congruence and facilitate economic decision-making by the profit center managers.

### 5.4.4 Service Quality

Deterioration of the quality of electric service in Bulgaria has become a matter of serious concern. In part, the poor quality of service can be attributed to inadequate operable generation as well as limited fuel supplies. To some extent the age of the distribution plant explains part of the problem. But operational problems and inadequate maintenance, as well as delays in responding to service complaints, are also partly to blame.

Problems of inadequate generation and outdated distribution facilities will require infusions of capital to refurbish and upgrade the physical facilities. To the extent that service quality is adversely affected by poor operation and maintenance and inadequate attention to service complaints, improvements also could be achieved by (1) privatization of distribution systems and (2) improved pricing.

Managers of privatized distribution operations (whether part of a fully integrated electric company or as separate distribution companies) seeking to maximize profits will have strong incentives to improve service quality, at least to the extent that this means reducing supply interruptions. So long as price exceeds out-of-pocket costs (essentially fuel cost), interruptions of service mean out-of-pocket losses. There are also costs associated with receiving and processing complaints, and labor and material costs of correcting the outage. Finally, there are indirect costs associated with unsatisfied customers who are less likely to pay bills promptly, and less likely to support the company in other aspects of its business.

The service quality of a privatized distribution company should be regulated by an independent agency, because companies have inadequate incentive to ensure reasonable quality of service to customers or may have an incentive to discriminate among its customers under some circumstances. This might occur, for example, if out-of-pocket



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among the numerous matters that must occupy the time and energy of ministers of the government. Further, the need to keep the Kozloduy plant in operation to ensure adequate power supply in Bulgaria necessarily creates pressure to reduce emphasis on health and safety requirements.

Consideration, therefore, should be given to creation of CAE as an autonomous agency with clearly defined responsibility for ensuring that health and safety requirements are met. The authority and responsibilities of this agency would have to be clearly set forth in law along with the health and safety standards that are to be enforced. A transitional period, during which Kozloduy is brought up to standard, may be desirable. For example, one possibility might be that during this transitional period, the orders of the agency could be overruled by the Council of Ministers, but only on the basis of a full written explanation made publicly available.

Following the transition period, not to extend beyond some reasonable and specific date, the CAE could be reconstituted by law as an independent agency with at least three members with equal voting power in decisions of the committee. At least two of these should be specialists in the fields of nuclear engineering, physics or chemical engineering. Each would be appointed by the Council of Ministers for fixed, staggered terms. Decisions of the CAE would be reviewable only by an appropriate court. An agency constituted in this way should be in a position to ensure the health and safety of the population without undue political influence.

## 5.4 REGULATION OF PRICES AND SERVICE

### 5.4.1 Roles of the Committee of Energy and the National Commission on Prices

To the extent that there is regulation of electricity prices and service, this function is performed by the Committee of Energy (COE) and the National Commission on Prices (Price Commission). The work of the COE is described in Appendix C3. Essentially it exercises responsibilities for policy analysis and implementation in the energy field.[1]

The relationship between the COE and the Natsionalna Elektricheska Kompania (NEK) is unclear. Some say that the COE generally reflects the wishes of the NEK. Soon after the NEK was established, the COE prepared the proposal for the first round of price

[1] Proposed tariffs for thermal energy and coal move through the COE before review by the Price Commission; proposed tariffs for electric power, however, move directly to the Price Commission without formal action by the COE. As noted in the text, however, these tariffs are developed largely by the COE in the first place.



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profit margins vary substantially among different customers groups or if the amounts of energy taken by customers vary substantially in different areas. The regulatory agency could have a procedure whereby those who are unsatisfied with their service or believe they are being discriminated against can complain to the regulatory authority. Unless the complaint is frivolous on its face, a response to the complaint would be required of the company. Investigation of the complaint by the agency staff may be necessary. Armed with information obtained in this way, the agency would be in position to resolve the complaint. Such resolution may simply be a determination that the complaint warrants no action. If action is warranted, it may take the form of a directive requiring some specific response by the company. Failure to respond to directives of the regulatory agency may subject the company to monetary penalties or other forms of coercion such as a reduced rate of return on the next time its rates are up for review.

Improvements in service quality may also be expected from improved pricing. The incentive to avoid interruption mentioned above stems from the assumption that price exceeds short-run marginal cost (SRMC).

## 5.5 REGULATION DURING TRANSITION

While establishment of a Bulgarian Energy Regulatory Agency with the responsibility and authority outlined in Appendix C4 may be appropriate for a privatized Bulgarian electric power industry the appropriate form of regulation during the transition period depends on the structure of the industry as it evolves. If the NEK were privatized, regardless of whether there is any disaggregation, some regulation would be necessary. If, on the other hand, the state retains ownership of all of the assets of the electric power industry, the need for an independent regulatory authority is much less clear.[3] At the moment, ownership of the assets of the power industry is vested in the COE, although the new law currently in draft form appears to contemplate private ownership, possibly with some disaggregation (e.g., the introduction of independent power producers into the generation market).

[3] For example, in the United States, the FERC has the authority to determine the overall revenue requirements of the Bonneville Power Administration (BPA) as well as to fix the rates at which it sells power into California, even though BPA is a part of the U.S. Department of Energy. The Tennessee Valley Authority, on the other hand, is unregulated.

### 5.5.1 Draft Legislation

As currently drafted, the proposed legislation would vest comprehensive authority for regulation of the electric power sector in the COE.[4] While significant parts of the legislation vest control in the Council of Ministers (e.g., control of prices of electric energy),[5] it is apparent that, since the control is to be based on proposals by the Committee of Energy, the COE will hold most of the authority and responsibility. In addition to price control, COE authority over electric utilities would extend to:

- Issuance of licenses for production, transmission, and distribution of electricity
- Issuance of rights to build, extend, or renovate bulk power facilities
- Approval of proposals to import or export electricity
- Operation requirements for bulk power facilities
- Investment plans of electric utilities
- Environmental protection
- Service quality
- Information requirements.

### 5.5.2 Need for Independence

While the draft legislation describes the authority and responsibility of the COE in some detail, as well as the obligations of the regulated entities, it is silent on the organizational structure of the Committee of Energy. It is reasonably clear, however, that the COE would continue to operate as an arm of the Council of Ministers. This may be reasonable if the enterprises regulated by the COE are state-owned, but less so if one or more of the enterprises become privatized. Independence of the regulatory authority from the executive and legislative branches of government is essential in order to minimize political considerations in the implementation of policies designed to optimize efficiency and equity. It is also important as a means of encouraging private (domestic or foreign) investment in the assets of the electric power sector.

[4] Appendix C5 contains a summary outline of some of the more important features of the draft legislation at a fairly early stage in its development.

[5] The draft legislation does not mention the Price Commission.

# APPENDIX A

*Central Dispatch*

*Examples of Functional Descriptions with Linkage Diagram Flowchart*

# A.0 FUNCTIONAL DESCRIPTIONS AND LINKAGE DIAGRAMS OF FUNCTIONS

As referenced in Chapter 3.0, Central Dispatch, below are examples of functional descriptions taken from a recent MIS feasibility study with linkage diagrams of the functions shown in Figure A-1.

**Circuit Maps**

Description: Reproducible drawings containing power circuit information

Inputs: Existing drawings are updated with field information

Process: Each week. engineering and operations staff identify field changes on existing drawings. These drawings are redrafted to incorporate updates within a few days of receipt of changes. Drawings are distributed by Distribution Engineering to Power Distribution yards and Power Distribution dispatchers.

Outputs: Updated drawings.

Problems: Process is manually intensive, drawing information represents week-old data. Accurate map information is accessible at one location only. Improved access is desirable.

**Contract Development**

Description: Preparation of plant equipment and engineering service contracts.

Inputs: Standard contract documents

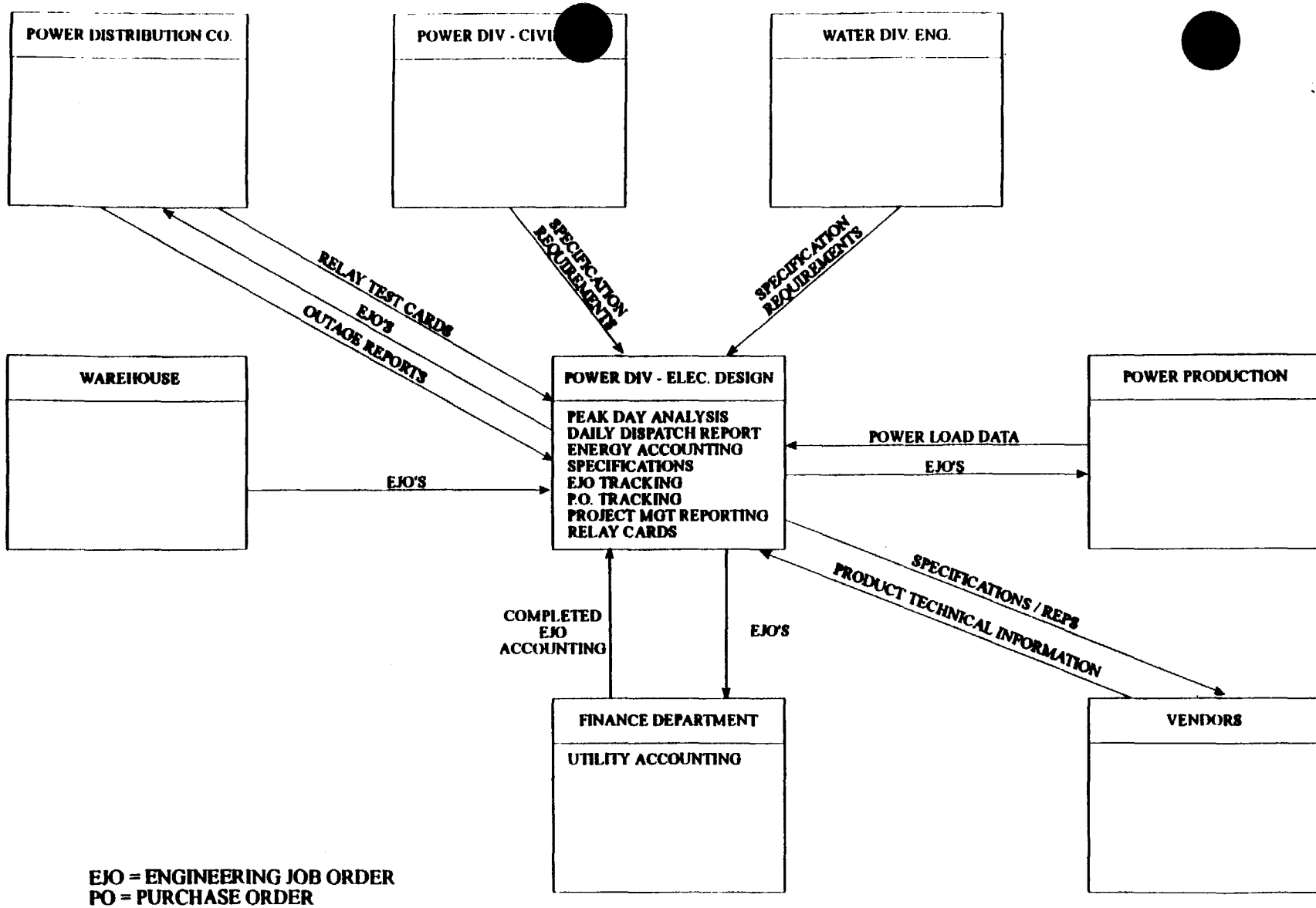
Process: Appropriate legal and financial sections, received from the business operations group, and technical sections from mechanical engineering, are added to standard contract document text to produce draft contracts. Following bidding and evaluation, final contracts are developed with legal. business operations and mechanical engineering.

Outputs: Final contracts are sent to vendors and processed internally by Business Operations. Invoices for engineering services, equipment, and fuel are sent to the Finance Department.

Problems: Extensive document preparation and information transfer in the review process.

# APPENDIX B

*Action Plans*




EJO = ENGINEERING JOB ORDER
PO = PURCHASE ORDER

FIGURE A-1

# B.0 ACTION PLANS

This Appendix details the Action Plans for the National Electric Company of Bulgaria. Exhibit B-1 provides an index, by department, to the Action Plans, which are detailed in Exhibits B-3 through B-21. A legend for the Action Plans is given in Exhibit B-2.

| NEK Action Plans | INDEX OF ACTION PLANS | Exhibit B-1 |
|---|---|---|
| **Exhibit** | **Corporate Finance Division** | |
| B-3 | Implement basic budgeting and control concepts and information systems | |
| B-4 | Establish a formal financial planning process | |
| B-5 | Implement improved cash management systems | |
| B-6 | Update and formalize the policy and procedure manuals for the accounting and finance function | |
| B-7 | Establish an internal audit function | |
| B-8 | Expand resources as necessary to develop a professional accounting and finance function | |
| B-9 | Upgrade basic accounting systems | |
| | **Development and Investment Division** | |
| B-10 | Consider consolidating the division with a newly formulated corporate planning function | |
| | **Electricity Supply Branches** | |
| B-11 | Consolidate the 28 existing branches into a smaller number of larger branches | |
| B-12 | Initiate a program to increase the company's control of meters | |
| B-13 | Use caution in evaluating the acquisition of advanced meter reading technologies | |
| B-14 | Separate the reporting of transmission losses from distribution losses | |
| | **Generation Division** | |
| B-15 | Expand the size and responsibilities of the headquarters staff | |
| B-16 | Study the possibility of establishing the nuclear operations as a separate division | |
| | **All Departments** | |
| B-17 | Consider consolidating this function under a vice president of administration | |
| | **Legal Department** | |
| B-18 | Explore the possibility of consolidating more of these attorneys at the headquarters | |
| | **Office of the President** | |
| B-19 | Develop and implement an automated executive service information system (EIS) to facilitate the monitoring of key orders of the Supervisory and Managing Boards | |
| | **Personnel Department** | |
| B-20 | Implement a project to automate the company's personnel records | |
| B-21 | Consider expanding the scope of responsibilities of the Personnel Department | |

| NEK Action Plans | LEGEND | Exhibit B-2 |
|---|---|---|

**RECOMMENDATION**

A description of the recommendation.

**MAJOR STEPS**

An outline o .ne major steps or phases required to implement the recommendation.

**RESOURCES REQUIRED**

Suggests the division, department, or position to be given the overall responsibility for implementing the recommendation and outlines the nature of the resources required.

**SCHEDULE**

Indicates the estimated sequence of events for the major steps and provides an estimate of the timing required.

**ESTIMATED COSTS AND BENEFITS**

Provides an estimate of the order-of-magnitude costs (both one-time and recurring) and expected benefits from implementation of the recommendation.

**Action Plan** | **CORPORATE FINANCE DIVISION** | **Exhibit B-3**

## RECOMMENDATION

Implement basic budgeting and control concepts and information systems.

## MAJOR STEPS

- Identify and appoint budget staff.
- Develop a conceptual design for the budgeting process.
- Identify computer systems requirements.
- Identify the information flows, work flows, and a timetable.
- Develop and disseminate budget instructions and forms.
- Conduct training sessions for those to be involved.

## RESOURCES REQUIRED

- Guidance from a knowledgeable expert in the area of budgeting.
- Training.
- Budget analysts.
- Computer resources.

## SCHEDULE

- Appoint key staff by June 30, 1993.
- Complete conceptual plan, including computer system requirements, by September 30, 1993.
- Complete information flows, etc. by September 30, 1993.
- Develop and disseminate budget packages by September 30, 1993.
- Conduct initial training sessions by September 30, 1993.
- Initiate budget cycle by October 1, 1993.
- Conduct continuous training through the completion of the budget cycle.

## ESTIMATED COSTS AND BENEFITS

- The costs include the cost of the headquarters budget unit staff, the cost of any budget clerks/analysts required by the branches, and the cost of computer resources.

- The principal benefits include a better understanding of costs on the part of the managers responsible for controlling them and the resultant improved cost control.

**Action Plan** | **CORPORATE FINANCE DIVISION** | **Exhibit B-4**

## RECOMMENDATION

Establish a formal financial planning process.

## MAJOR STEPS

- Identify or recruit planning analysts.
- Define the responsibilities of the Financial Planning group.
- Identify financial planning requirements (outputs).
- Identify information system requirements.
- Develop a conceptual design of the financial planning process.
- Identify information flows, work flows, and a timetable.
- Conduct training sessions.
- Develop a schedule to inaugurate the financial planning process.

## RESOURCES REQUIRED

- Guidance from knowledgeable expert(s) in financial planning.
- Financial analysts.
- Computer resources.
- Training.

## SCHEDULE

- Recruit staff by June 30, 1993.
- Complete conceptual design and system needs by August 30, 1993.
- Identify information flows, etc. by October 30, 1993.
- Complete initial training by September 30, 1993.
- Complete schedule to inaugurate financial planning process by October 31, 1993.

## ESTIMATED COSTS AND BENEFITS

- The costs will include financial analysts, computer systems, and any financial planning models considered appropriate.

- The benefits will include an enhanced ability to serve the information needs of senior management and the ability to comply with the information needs of international lenders.

| Action Plan | CORPORATE FINANCE DIVISION | Exhibit B-5 |
|---|---|---|

**RECOMMENDATION**

Implement improved cash management systems.

**MAJOR STEPS**

- Document and provide flow chart of existing flows of cash, indicating amounts, timing, frequency, etc.
  - Trace the cycle from meter reading through billing and collection, and including deposits to banks.
  - Include the management of cash after deposit, including the management of accounts payable.
- Identify recommendations for improvement.
- Develop action plans to implement recommendations.

**RESOURCES REQUIRED**

- For the audit of the company's cash system, the key resource is technical assistance from expert(s) in assessing cash management.
- The resources required to implement any recommendations cannot be determined at this time.

**SCHEDULE**

- Given the fact that Bulgaria's economy is essentially a cash economy, this will be a limiting factor in achieving an advanced cash management system for NEK. Nonetheless, NEK should identify those improvements that can be implemented now.
- Complete the review of NEK's cash systems and processes by October 31, 1993.
- Develop implementation plans by December 31, 1993.

**ESTIMATED COSTS AND BENEFITS**

- The net benefits (after deducting costs) should be substantially, even though they are not quantifiable at this time.

| Action Plan | CORPORATE FINANCE DIVISION | Exhibit B-6 |
|---|---|---|

**RECOMMENDATION**

Update and formalize the policy and procedure manuals for the accounting and finance function.

**MAJOR STEPS**

- Identify the key policy issues and procedures for the accounting and finance function.
- Obtain and review sample policy and procedure manuals from other electric utility organizations.
- Develop a preliminary draft of both manuals.
- Review and finalize the manuals. The reviewers should include the Management Board and the Board of Bank Managers.

**RESOURCES REQUIRED**

- Guidance from expert(s) knowledgeable in financial policies and procedures.
- The time and effort of one or more members of the financial staff.

**SCHEDULE**

- Identify key policy issues and procedures by July 31, 1993.
- Obtain and review a representative sample of manuals by September 30, 1993.
- Complete preliminary draft by December 31, 1993.
- Finalize policy and procedure manuals by March 31, 1994.

**ESTIMATED COSTS AND BENEFITS**

- The costs of this recommendation should be minimal. They will relate to the time of those who develop the manuals.
- The benefits include a clearer definition of the direction for the accounting and finance function and a better understanding on the part of those who work in the division.

**Exhibit 2-10**
**Department Profile: Personnel Department**



## GENERAL DESCRIPTION

The major responsibilities of the Personnel Department are to: 1) appoint new hires, 2) maintain vacation and pension records, and 3) process employee terminations for all headquarters employees, including the Central Dispatch group. The total number of employees for whom records must be maintained is about 450. Most of what this department does is concerned with the processing of documents. And substantially all of the records and documentation are manually maintained. The records that must be maintained include:

- Employee files
  - Correspondence
  - Curriculum vitae
  - Diploma
  - Medical exam
  - Signature card
  - Labor card
  - Results of a check of court records
- List of employees on sick leave
- Requests for vacation time
- Identification cards
- An employee register, listing date of birth, the labor contract number, job title, date of hire, date of termination, and any notes or comments
- Pension notices
- Pension folders for all employees
- Maternity leave folders
- Employee contract folders
- Folders for all outside work
- Penalty Act records
- Vacation schedules.

The department processes all vacation, termination and pension data. Each of the branches has a similar personnel function with the same responsibilities.

## CURRENT STRUCTURE

The Personnel Department at NEK's headquarters consists of two people. One acts as department head and the second is a personnel specialist. The department head is, in effect, a working lead (as opposed to having only management or supervisory responsibilities).

## KEY COORDINATING MECHANISMS

Direct supervision is the key coordinating mechanism in a department as small as this. In addition, the nature of work processes is highly prescribed due to the existence of employment laws and regulations.

## DESIGN PARAMETERS

**Work Specialization** - The work of this department requires knowledge of the employment laws and regulations of Bulgaria. Otherwise, it requires knowledge of the various specialized forms, documents and reports -- and the associated procedures -- required by the system.

**Training and Indoctrination** - The job requirements of the department can be acquired through specialized training programs and on-the-job training.

**Formalization of Activities** - As is true in most industrialized nations, there are many specific laws and regulations governing most matters pertaining to employees. Consequently, most tasks are highly defined in terms of what must be done in specific instances.

**Unit Size** - The unit size is extremely small on an absolute and relative basis.

**Planning and Control Systems** - Little formal planning and control is necessary due to the small size of the group and the well-defined and legally prescribed nature of the work.

**Liaison Devices** - The Personnel Department acts solely in a staff support capacity and its needs for liaison with other departments are limited beyond the formal handoffs necessary to process employee data.

## OBSERVATIONS AND CONCLUSIONS

**The scope of responsibilities of the personnel department is narrowly defined.** The responsibilities of the personnel department are limited to maintaining the legally required documentation for employee actions. In addition to these matters -- essentially personnel administration -- there are several other responsibilities that are now typically included as part of a more broadly defined human resources department. They include the following:

- Training and development
- Compensation and benefits management
- Safety management
- Organizational planning.

**Responsibility for personnel matters is diffused throughout the organization.** The headquarters for personnel function is responsible only for its own employees plus those in Central Dispatch. Otherwise,each branch maintains its own personnel department, which performs the same activities. Although there are certain human resource management activities that naturally should be performed locally, there are others -- especially certain of the personnel administration tasks -- that can be centralized. Centralization may require automation of the personnel records, but this should be done anyway.

**Almost all personnel records are manually maintained.** Substantially all of NEK's personnel records are manually maintained. And while certain of them (e.g., each employee's labor card) are required by law, there are many elements of information that could be automated. As the organization continues to become more complex and competitive, the personnel function will be expected to go beyond its personnel administration responsibilities. Automation of existing records (to the maximum extent possible) should be performed as a first step to enable the orderly expansion into a broader set of responsibilities. Even if it is decided to restrict the Personnel Department to its current administrative responsibilities, these records should be automated.

## RECOMMENDATIONS

**Consider expanding the scope of responsibilities of the Personnel Department.** In addition to its existing responsibilities -- essentially personnel administration -- there are several other responsibilities that are now typically included as part of a more broadly defined human resources department. They include the following:

- Training and development
- Compensation and benefits management
- Safety management
- Organizational planning.

As NEK continues to implement advanced management techniques necessary to function effectively in a market oriented economy, it will become increasingly more important to make the best use of its human resources. The fact that labor costs are low does not justify squandering this resource. If the company is successful, this complex of activities will become increasingly more important to sustaining success. NEK should begin now to build a broadly defined human resource management function.

**Implement a project to automate the company's personnel records.** The automation of existing records (to the maximum extent possible) should be performed as a first step to enable the orderly expansion of the personnel function into a broader set of responsibilities. Even if it is decided to restrict the department to its current administrative responsibilities, these records should be automated to improve efficiency.

**Explore the feasibility of consolidating personnel activities.** NEK should explore the feasibility of streamlining the personnel function in tandem with an expansion of the department's responsibilities. In all likelihood, there will always be certain human resource management activities that naturally should be performed locally. But there are others -- especially certain of the personnel administration tasks -- that can be centralized. Centralization may require the automation of the personnel records, but this should be done anyway.

# 3.0 ORGANIZATION OF NEK'S NATIONAL DISPATCH CENTER AND OPERATIONS MANAGEMENT INFORMATION SYSTEM

## 3.1 BACKGROUND AND ORGANIZATION FOR THIS REPORT

### 3.1.1 Background

Hagler, Bailly reviewed the area of power systems *operations*, including a limited review of NEK's EMS/SCADA system. We were concerned that there might be some duplication between our work and that sponsored by the European Community (EC). The written instructions provided to Hagler, Bailly were based on U.S.A.I.D.'s Terms of Reference and specifically included an analysis of NEK's Central Dispatching system. bu urged that there be complete exchange of information with the EC transmission consultant.

As the result of meetings with a representative of ESB International (ESBI) who was responsible for organizing the EC funded project in Generation and Transmission, the review was reorganized to include Energy Management System/Supervisory Control and Data Acquisition (EMS/SCADA), and to address the subject of Operations Planning, which is often not included in the definition of EMS/SCADA technology. The Venn diagram (Figure 3-1, below) presents the difference between Hagler, Bailly's assignment and the EC's in connection with the Central Dispatching analysis.

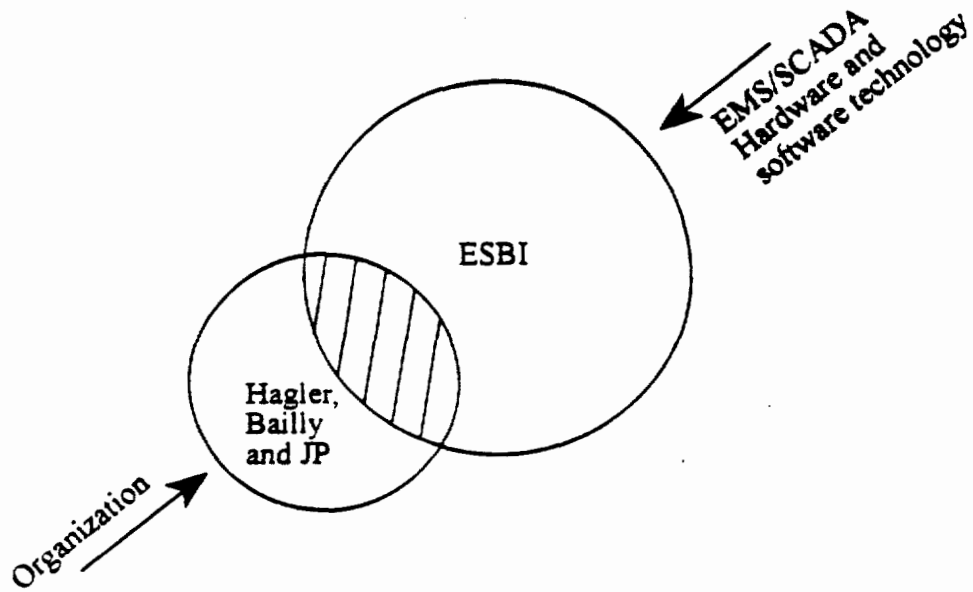



**Figure 3-1: Venn Diagram of the Central Dispatching Analysis Studies**

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The diagram shows that the EC's effort is significantly larger than Hagler, Bailly's in the EMS/SCADA area, that some overlap is acknowledged, and that the EC emphasizes technology, whereas Hagler, Bailly emphasizes organization.

The situation is further complicated by the fact that ESBI does not have the assignment to study Central Dispatching, but to determine the Terms of Reference (TOR), which we usually call Statement of Work, of another European consultant who, according to an ESBI representative, would commence work in November 1992. The budget set aside for the Generation and Transmission element is $1.3 million out of the total budget (excluding the nuclear safety problem of Kozloduy) of $13 million allocated to the Committee of Energy (COE) by the EC. The $1.3 million portion includes the analysis of an interconnection with UCPTE.[1] Hagler, Bailly did not see ESBI's Terms of Reference in EMS/SCADA, most probably because the TOR had not been sanctioned yet by Brussels, nor the budget, although it was estimated to be in the range of $300,000 to $400,000. A fraction of the $300-400k slice was to be spent by ESBI to help the World Bank evaluate COE's application for the EMS/SCADA modernization, which is discussed later in this chapter.

The relations between COE and NEK as well as the internal organization of NEK are shown in Figure 3-2. The block that is most relevant to the EMS/SCADA function is Central Dispatch Control.

An additional complication to this study is a World Bank loan application by the Bulgarians to complete and expand an EMS/SCADA system dating back to 1982. The vendor, Landis and Gyr of Switzerland, is still under contract and so is the project consultant, EnergoProekt of Sofia, formerly a division of the same Ministry that contained NEK and now a large independent A&E firm. The International Bank for Reconstruction and Development (IBRD) just completed a mission in the course of which the EMS/SCADA application was reviewed.[2]

Procuring key documents in English proved difficult in this task. On the last day of the study we received a 50-page document,[2] which describes what improvements to the EMS/SCADA system are believed to be necessary. A spot-check of their proposal (the EMS portion only was reviewed) indicated a good understanding of the technology and a balanced view of how much is really needed.

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[1] UCPTE - *Union pour la Coordination de la Production et du Transport de l'Electricité.* It is basically the Western European Power Pool.

[2] Draft project for financial assistance "Energy Management System Development." No source or date is given for the document. The subcontractor believes it was authored by EnergoProekt two years ago.

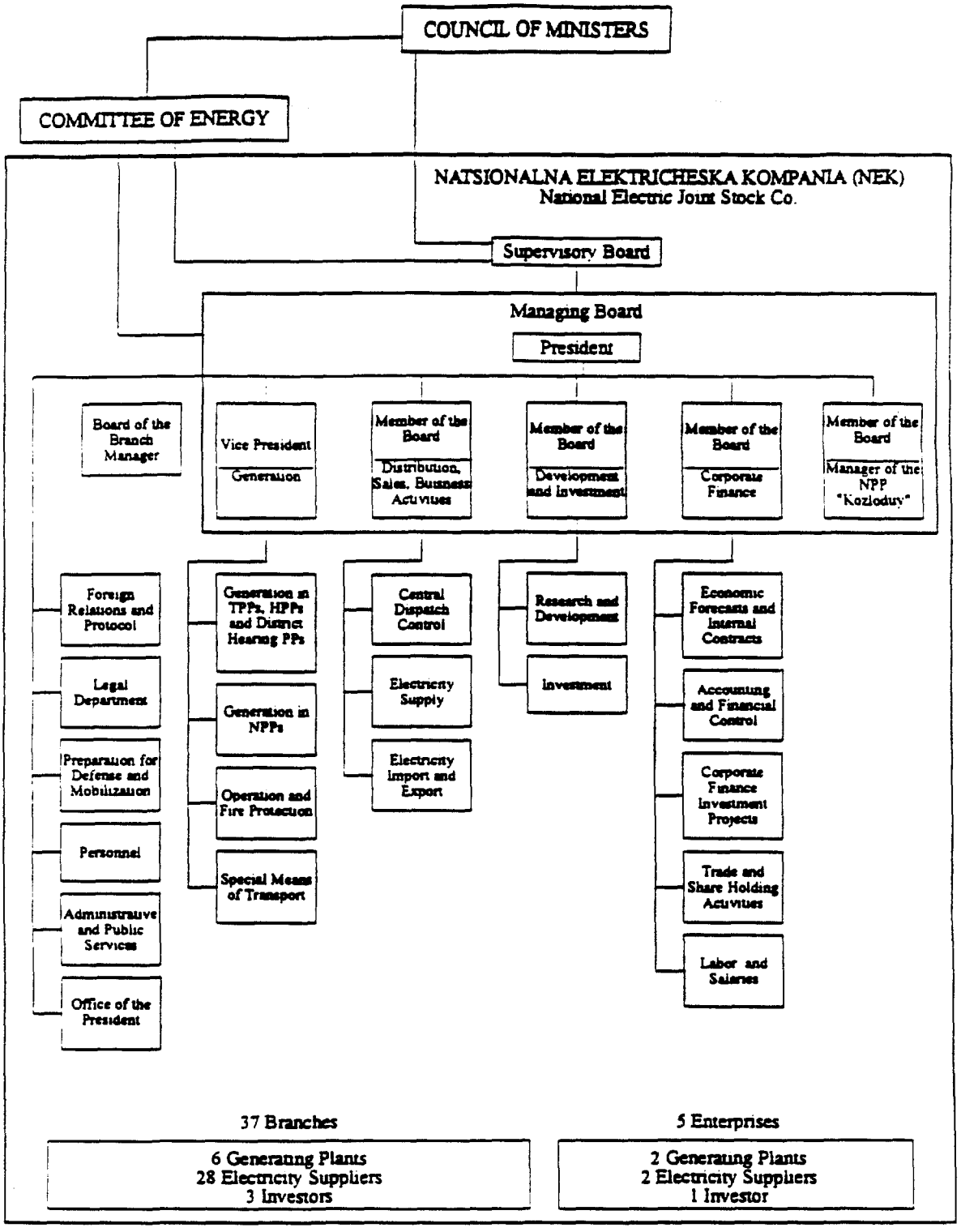


Figure 3-2 NEK Organization Chart

**Action Plan** | **CORPORATE FINANCE DIVISION** | **Exhibit B-7**

## RECOMMENDATION

Establish an internal audit function.

## MAJOR STEPS

- Identify the mission of the internal audit function and develop a preliminary proposed work plan.
- Estimate the staffing needed to accomplish the proposed work plan.
- Recruit and train appropriate staff.

## RESOURCES REQUIRED

- Staff personnel with appropriate backgrounds and training.
- Technical advisory guidance from expert(s) knowledgeable in internal auditing.

## SCHEDULE

- Identify the unit's mission and proposed audit plan by September 30, 1993.
- Recruit and train staff by December 31, 1993.

## ESTIMATED COSTS AND BENEFITS

- The largest single cost will be the cost of additional staff.
- The benefits will be enhanced compliance with accounting and operational policies and procedures, and improved internal accounting controls.

| Action Plan | CORPORATE FINANCE DIVISION | Exhibit B-8 |
|---|---|---|

## RECOMMENDATION

Expand resources as necessary to develop a professional accounting and finance function.

## MAJOR STEPS

- Identify those elements of the accounting and finance function that will be required for NEK.
- Prioritize the various elements in terms of importance, sequence, and timing.
- Develop a plan to recruit and train key staff.
- Identify the implementation resources required (procedure development, professional guidance in developing key processes, staff training and development, etc.).

## RESOURCES REQUIRED

- The key resource will be professional staff for the expanded function.
- Training and development will be a critical activity.
- Outside assistance will be needed in establishing key processes.

## SCHEDULE

- Identify priorities and develop a recruitment plan by September 30, 1993.
- Obtain agreement for outside assistance by September 30, 1993.
- Establish milestones based on the final budget approved for this activity.

## ESTIMATED COSTS AND BENEFITS

- The single greatest cost will be the cost of recruiting and training the professional and administrative staff.
- Other costs will include costs for facilities, computers, and accounting systems (see other recommendations).
- The benefits will include compliance with mandatory financial filings and improved planning and decision making by management.
- A strong corporate finance and accounting group is essential for success in a market-oriented economy. These expenditures should not be viewed as optional.

**Action Plan** | **CORPORATE FINANCE DIVISION** | **Exhibit B-9**

## RECOMMENDATION

Upgrade basic accounting systems.

## MAJOR STEPS

- Develop an invitation to submit qualification statements.
  - Circulate to major software vendors and accounting firms.
- Select a firm or firms to assist NEK.
- Conduct a needs assessment study.
- Develop a preliminary information systems plan.

## RESOURCES REQUIRED

- Know-how: This will include firms with expertise in implementing large-scale systems, as well as technical and management guidance for the overall program.
- Computer resources, including hardware and software. This will likely be a major cost.

## SCHEDULE

- Develop an RFQ (request for qualifications) by June 30, 1993.
- Select a firm or firms to assist by September 30, 1993.
- Conduct a needs assessment study by December 31, 1993.
- Develop a preliminary information systems plan by March 31, 1994.

## ESTIMATED COSTS AND BENEFITS

- This will likely be a very large-scale investment. Before it is completed, this activity could easily require spending hundreds of millions of leva.
- It will be difficult for NEK to achieve better co[illegible]ol over its operations without better accounting and information systems. The bene[illegible] may be difficult to quantify, but are compelling nonetheless.

| Action Plan | DEVELOPMENT AND INVESTMENT DIVISION | Exhibit B-10 |
|---|---|---|

**RECOMMENDATION**

Consider consolidating the Investment Department, making it part of the corporate finance function.

**MAJOR STEPS**

- Determine whether the skills and resources represented by the Development and Investment Department are a good fit with the corporate finance function.
- If yes, then consolidate these two groups.

**RESOURCES REQUIRED**

- The evaluation and decision should be made by NEK's senior management.

**SCHEDULE**

- Determine whether NEK should establish a separate corporate planning function by September 30, 1993.
- If yes, develop mission and outline responsibilities, and then assess whether there is a good fit between corporate planning and development and investment by December 31, 1993.

**ESTIMATED COSTS AND BENEFITS**

- The costs to make the determination will be minimal.
- If the decision is made to develop a corporate planning function *and* to incorporate the Development and Investment Division, then the incremental cost of developing a corporate planning function will be lowered.

**Action Plan** | **ELECTRICITY SUPPLY BRANCHES** | **Exhibit B-11**

## RECOMMENDATION

Consolidate the 28 existing branches into a smaller number of larger branches.

## MAJOR STEPS

- Conduct a study to determine the optimum configuration (number, size, and location) of branches.
- Develop an implementation plan and schedule.

## RESOURCES REQUIRED

- For the initial study, this can be done by internal staff with assistance from technical advisor(s) with experience in this area.
- Implementation resources will be similar.

## SCHEDULE

- Complete the initial study by September 30, 1993.
- Finalize an implementation plan and schedule by December 31, 1993.

## ESTIMATED COSTS AND BENEFITS

- The incremental costs of the study should be minimal.
- The costs of reorganizing will vary in relation to the configuration selected and the extent to which it maximizes the use of existing resources.
- The benefits will include more effective management, higher quality of service, and potentially lower costs.

**Action Plan** | **ELECTRICITY SUPPLY BRANCHES** | **Exhibit B-12**

## RECOMMENDATION

Initiate a program to increase the company's control of meters.

## MAJOR STEPS

- Conduct a study to specify and quantify the nature and extent of the problem.
- Identify possible corrective actions, including managerial, technical, and legal.
- Develop an action plan and schedule to implement corrective action.

## RESOURCES REQUIRED

- For the initial study, this should be done by internal resources with assistance from technical advisor(s) knowledgeable in this area.
- For any follow-on implementation program, additional resources may be required.

## SCHEDULE

- Conduct the initial study by September 30, 1993.
- Evaluate possible corrective actions by November 15, 1993.
- Develop an implementation plan and schedule by December 31, 1993.

## ESTIMATED COSTS AND BENEFITS

- The incremental costs of conducting the initial study should be moderate.
- The costs of implementing any recommendations cannot be determined at this time.
- The benefits will include revenue enhancement as a result of improved metering.

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| Action Plan | ELECTRICITY SUPPLY BRANCHES | Exhibit B-13 |
|---|---|---|

**RECOMMENDATION**

Use caution in evaluating the acquisition of advanced meter reading technologies.

**MAJOR STEPS**

- Ensure that the appropriate engineering-economic methodology is applied to these analyses.

**RESOURCES REQUIRED**

- No incremental resources will be required beyond those internal resources that will conduct the evaluation of these technologies.

**SCHEDULE**

- Same as schedule to evaluate the meter reading technologies.

**ESTIMATED COSTS AND BENEFITS**

- No incremental costs.
- The benefits include greater assurance that the decision regarding the acquisition of these technologies will be cost-effective.

**Action Plan** | **ELECTRICITY SUPPLY BRANCHES** | **Exhibit B-14**

## RECOMMENDATION

Separate the reporting of transmission losses from distribution losses.

## MAJOR STEPS

- Conduct a study to determine what actions would be required to establish reporting of transmission losses and distribution losses separately.
- Evaluate the recommended actions and develop an implementation plan as appropriate.

## RESOURCES REQUIRED

- This study should be conducted by internal staff.

## SCHEDULE

- Conduct the initial study by September 30, 1993.
- Evaluate the recommended actions and develop an implementation plan by December 31, 1993.

## ESTIMATED COSTS AND BENEFITS

- The incremental costs of conducting the study should be minimal.
- The costs of implementing any recommended action plan cannot be determined at this time.
- The benefits include better insight into the causes of electricity line losses.

| Action Plan | GENERATION DIVISION | Exhibit B-15 |
|---|---|---|

**RECOMMENDATION**

Expand the size and responsibilities of the headquarters staff.

**MAJOR STEPS**

- Conduct a survey of western utilities to assess the range of responsibilities of the headquarters generating functions.
- Define the responsibilities of NEK's Generating Division at the headquarters level.
- Develop an expansion plan and schedule as appropriate.

**RESOURCES REQUIRED**

- Internal staff, with technical assistance from outside experts.

**SCHEDULE**

- Complete a survey of western utilities by September 31, 1993.
- Define the responsibilities of NEK's Generating Division at the headquarters level by November 30, 1993.
- Develop an expansion plan by December 31, 1993.

**ESTIMATED COSTS AND BENEFITS**

- The incremental costs of conducting the study should be moderate.
- The costs of expanding the size of the headquarters group will consist of the additional staff skills needed (unless they can be transferred from other positions within the company).
- The benefit will be enhanced responsiveness and improved management controls.

**Action Plan** | **GENERATION DIVISION** | **Exhibit B-16**

## RECOMMENDATION

Study the possibility of establishing the nuclear operations as a separate division.

## MAJOR STEPS

- Conduct a study to identify the potential advantages of this concept.
  - Include visits to several nuclear utilities that have implemented this approach.
- Develop a recommendation and implementation plan and schedule as appropriate.

## RESOURCES REQUIRED

- This study should be conducted by internal staff resources with technical advisory assistance from outside experts.

## SCHEDULE

- Conduct the initial study by September 30, 1993.
- Evaluate recommendations and associated implementation plans by December 31, 1993.

## ESTIMATED COSTS AND BENEFITS

- The incremental cost of the study should be modest.
- The cost of implementing the study recommendations cannot be determined at this time.
- The benefits include more effective management of the company's nuclear resources.



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Action Plan

**ALL DEPARTMENTS**
**Administrative and Public Service Department,**
**Office of the President, Foreign Relations Department,**
**Personnel Department, and Legal Department**

**Exhibit B-17**

RECOMMENDATION

Consider consolidating this function under a vice president of administration.

MAJOR STEPS

- Conduct a study to detail and catalogue the responsibilities, activities, and resources among these administrative and corporate support activities.
- Assess the potential synergies from closer organizational linkages and consolidations within certain of the functions.
- Develop a proposal to consolidate and combine some or all of these groups.
- Review with the Managing Board.
- Modify as appropriate and develop an implementation plan.

RESOURCES REQUIRED

- This project should be conducted by an internal team with assistance from an independent specialist or firm with relevant expertise.

SCHEDULE

- Conduct the initial studies and develop a proposal to consolidate and combine some/all of these activities by September 30, 1993.
- Review with the Managing Board by October 31, 1993.
- Make modifications and develop an implementation plan by December 31, 1993.

ESTIMATED COSTS AND BENEFITS

- The incremental costs should be modest.
- The principal benefits include improved communication and coordination of these corporate support activities and better utilization of these staff resources.

In response to this suggestion, the Head of Investment Projects issued a request that a feasibility study of this concept be funded as a matter of urgency.

### 3.1.2 Organization of this Chapter of the Report

The remainder of this chapter will address the following questions in a preliminary manner:

- How elaborate should NEK's EMS/SCADA system be?
- What are the organizational structure, staffing, and qualifications of the Central Dispatch Control?
- What are the principal interactions among Central Dispatch Control and other departments within and perhaps outside of NEK?
- What should be the outline of a statement of work for the proposed Operations MIS?

## 3.2 HOW ELABORATE SHOULD NEK'S EMS/SCADA BE?

### 3.2.1 Defining EMS

A narrow definition of an Energy Management System would consist of functions such as economic dispatch and automatic generation control, which are executed on a time-scale of seconds or minutes. The EMS as normally defined today includes pre-dispatch, dispatch, and post-dispatch functions; that is, forecasting and scheduling in most cases. Sometimes missing from the EMS definition are energy accounting, billing, and similar post-dispatch functions.

The operations division of an electric utility is, and has always been, responsible for "operations planning" — the scheduling of generation, transmission, interchange, and other contracts and fuel use over periods of typically weeks and sometimes years. To perform operations planning, complex and computation-intensive computer aids have been developed.

Many utilities now include operations planning in their definition of EMS. This makes good sense because the operations planning staff is often, though not always, located on the dispatch center premises. Also, the trend is now for the dispatch computer(s) to also perform the operations planning calculations. This trend has been accentuated with the advent of "open system" architecture, which makes it easy for an operations planning

- Although there are numerous linkages, including computer hardware and communications, between the EMS/SCADA and the OPS MIS, these two projects can be done almost independently.[4]

## 3.3 ORGANIZATION STRUCTURE, STAFFING, AND QUALIFICATIONS OF THE CENTRAL DISPATCH CONTROL

### 3.3.1 Background

The NEK organizational chart (Figure 3-2, above) was provided by NEK's Director General. An initial reaction is that the organization that he reports to is perhaps incorrectly named. In the West, this organization would typically be headed by a Vice President of Operations who would be responsible for operating the utility safely and economically on a minute-by-minute basis over a horizon of up to several years. He would be responsible for Electricity Supply and Electricity Import and Export. He would generally also be in charge of fuel planning and purchase, a function that is not explicitly shown in Figure 3-2. He usually would not become involved in low voltage (or secondary) distribution, nor in retail sales, but would be very much concerned with short-term (today for 1 hour) and long-term (next five years for a *variety* of internal sales and external transactions) contracts. He would most certainly supervise the operation of all generating plants, including district heating.

The fact that, at NEK, all generation reports to a different Vice President does not necessarily mean a real or incipient problem exists. The general rule, confirmed by the Director General, is that "Central Dispatch Control is ultimately responsible for the safe operation of the whole utility and will dictate the appropriate power levels to be produced by each plant. In an emergency, it will also curtail specific loads." However, it is our belief that the economic operation of NEK in terms of optimum operations planning and economic dispatch will require a good interaction between Central Dispatch Control and all types of generation.

No formal organization chart was available, but NEK's Director General supplied a hand-drawn chart (reproduced in Figure 3-3). A more detailed breakdown of the number and the qualifications of the 250 people reporting to the Director General was not available.

[4] Pacific Gas & Electric is an example of a successful and almost independent implementation. See Reference 4.

*workstation* to be plugged into the distributed computation network that the EMS *is* becoming.

The comments made for operations planning also apply to what we will term the "Operations MIS," which is the most recent trend and which is, again, made possible by the open system architecture and the availability of high-capacity utility telecommunications, such as fiber optic cables contained in the ground wire of high voltage transmission lines.

### 3.2.2 Preliminary Findings

Since NEK and its predecessor have been collaborating with Landis & Gyr since 1982 in upgrading the SCADA system and in planning the addition of the most essential EMS functions, namely automatic generation control consisting of LFC (load frequency control) and economic dispatch, and reactive power dispatch, it would seem that this effort should be speeded up. The history, need, and justification of this program can be found in Section 3.6, References No. 1 and 3. Furthermore, ESBI will retain a European consultant to review this background and provide the IBRD with a feasibility study by early 1993.

Since ESBI had not yet finalized the TOR of the European consultant, nor selected the consultant, it is not known if functions other than LFC/ED and reactive power dispatching will be added, and if so, when. Further, we do not know which, if any, of the operations planning functions will be included, and if so, when.

In response to the request that the EC and US AID consultants exchange information, findings and ideas, we offer the following two suggestions:

- Keep the traditional EMS simple and allow it to evolve in time
- Focus on the operations planning functions, because of their significant savings potential.

The Operations MIS will be discussed in more detail in Sections 3.3 and 3.5. Preliminary findings are as follows:

- NEK should immediately begin planning for an OPS MIS.
- This OPS MIS should in no way slow down the modernization of the EMS/ SCADA.

### 3.3.2 General Observations

The following general observations can be made:

- The hierarchical dispatching structure consisting of a Central Dispatch Center is characteristic of Eastern European utilities and will in all likelihood disappear or shrink significantly once an effective SCADA system and good inter-utility communications including mobile communications have been installed.

- Pacific Gas & Electric (PG&E) of San Francisco, the largest U.S. investor-owned utility, has one Central Dispatch and a number of regional maintenance and repair organizations, but all operational information is gathered in San Francisco and all control decisions originate in San Francisco. The total staff of PG&E's dispatch center is 123.

- While, from a cost point-of-view, reducing the staff of dispatching from 250 to a smaller number may not be very important, the time delays (and opportunities for mistakes) that are inevitable when communication flows up through a hierarchy and decisions flows down is very important and, unfortunately, almost impossible to quantify in terms of monetary benefits.

It was confirmed that at this time, NEK does not have a department that handles exports and imports efficiently. In the past, this function was performed by "Energo Export." Observations in light of this knowledge follow:

- There should have been a strong linkage between Energo-Export and Central Dispatch in the past because "A" should not sell what "B" does not have.

- In the future, and with an open European power market, the import-export function and a computer-supported trading section with knowledge of the whole gamut of possible interchange contracts will be essential.

Another area in which the operations function may need strengthening is that of demand side management (DSM). DSM includes conservation and voluntary curtailment by the customer with appropriate price incentives.
NEK has automatic emergency load curtailment which is triggered by underfrequency conditions. In addition, the dispatcher can order telephonically that selected customers be switched off. In most European countries, including Hungary, a central load management system or "ripple control" is used as a rather slow-acting method of load reduction to assist in case of supply shortage, but not in emergencies. There was no mention of such a system at NEK.

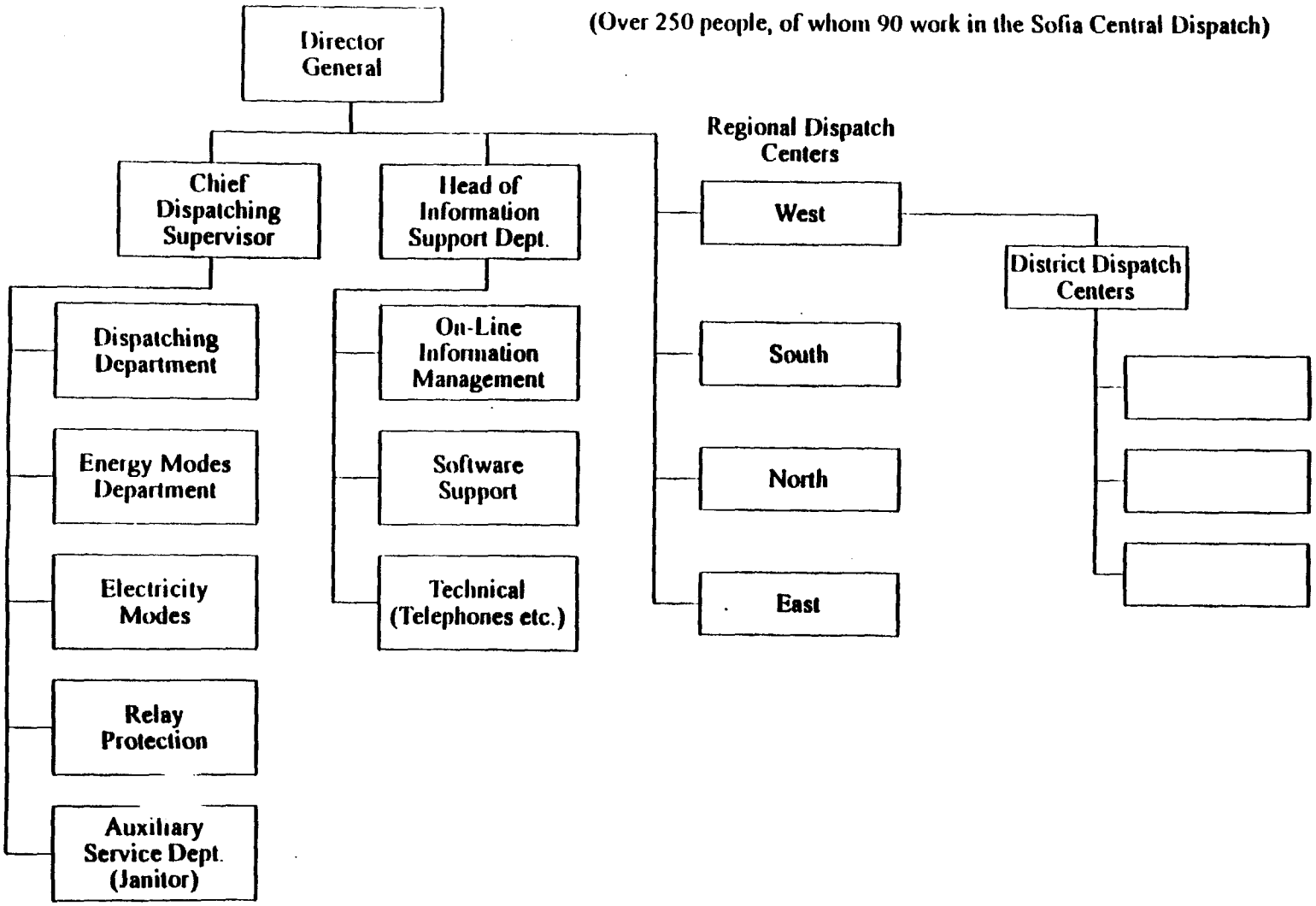


Figure 3-3 Organization Chart of the National Dispatching Center



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**NEK Operations Functions Checklist and Organizational Effectiveness Preliminary Evaluation**

| | Checklist | Preliminary Evaluation |
|---|---|---|
| 1. | Relation to plants, high voltage transmission, primary and secondary distribution | AGC (automatic generation control) is inadequate. Power plant controls are inadequate. Transmission and distribution controls (i.e., SCADA) will be improved. |
| 2. | International exchange, UCPTE requirements, economic transaction evaluations, billing | NEK is not in a position to handle the complex international exchanges that are likely to become a fact of life with expanded Western interconnections. |
| 3. | Authorization of generation and transmission equipment outages | Central Dispatching has the authority. A MIS would improve the rationality of outage decisions. |
| 4. | Management of generation and transmission loading (operations planning) - Fuel use planning | The organization exists. MIS and computer aids in optimized resource allocation are needed for both load and fuel planning. |
| 5. | Coordination of maintenance | Same as No. 4. |
| 6. | Recommendation of facility additions | Operations needs to interact with the Generation and Transmission department to identify near- and long-term needs. The effectiveness of this interaction is unclear. A MIS would help. |
| 7. | Definition of operating criteria, such as monograms which define loading limits of HV lines . . . | Same comment as No. 6. |
| 8. | Accurate and timely operations reports to management, planners and others within and outside NEK. These should include statistical information derived from actual operating data. | The status of this function is unclear. |

**Figure 3-4: Checklist of operations functions and preliminary evaluation of NEK organizational effectiveness**

NEK does not seem to have a well-organized capacity deferment scheme, and there was no discussion of conservation schemes, which reduce both capacity and energy demand.

A checklist (Figure 3-4) summarizes the preliminary organizational evaluation and may be used to obtain more precise answers in the future.

## 3.4 PRINCIPAL INTERACTIONS AMONG CENTRAL DISPATCH CONTROL AND OTHER DEPARTMENTS WITHIN AND OUTSIDE OF NEK

As shown in Figure 3-4, two of the most important interactions to consider are Central Dispatch's interaction with:

- Power plants, to coordinate maintenance and set production levels
- Generation and transmission planning, to recommend facility additions and define operating criteria.

The following incident, reported to Hagler, Bailly, underlines the importance of these interactions: Central Dispatching Control exported a large amount of bulk power. NEK lost money because the financial end of the transaction was handled incorrectly. The organization was missing a linkage to someone with expertise in international finance.

The identification of the very large number of detailed interactions that involve the operations function within NEK is beyond the scope of this report. This identification must be documented if and when NEK establishes an operations MIS.

To illustrate the complexity of these interactions, one example is taken from an account of the Energy Analysis Department's operations plan, which estimates the utilization of NEK's generation, transmission, and power import-export resources by week with a yearly horizon. Following is an annotated list of these interactions.

- Emergency import potential
- Load curtailment potential
- Operation of high pollution coal plants.

It is evident that this one — out of a number of applications — requires inputs and decisions from many individuals within and outside of NEK. It would be helpful if these interactions could be spelled out systematically as is suggested in Appendix A. The material of Appendix A could be gathered by NEK personnel collaborating with a feasibility consultant. It would be a key component of the feasibility study needed to design and justify the OPS MIS.

## 3.5 OUTLINE OF A STATEMENT OF WORK FOR THE PROPOSED OPS MIS

### 3.5.1 Introduction

The purpose of the OPS MIS is to take advantage of the recent technological development in distributed computing, high capacity telecommunications, local and wide are networks (LANs and WANs), and software portability to exchange operations related information quickly among Central Dispatch Control and others within NEK and, in specific instances, outside.

The OPS MIS can be, and in some cases is, a subset of a corporate MIS which includes but is not limited to information relevant to operations.

One extremely important characteristic of a correctly conceived MIS is data integrity — that is, assurance that the information contained within the MIS was derived from the same carefully checked input data. This almost always requires the discipline of single point data entry.

Another extremely important characteristic is controlled access — that is, the selection of those who may request specific databases and those who may alter, correct, or eliminate data.

A final extremely important characteristic is psychological: the ease with which people from different departments interact directly, that is, without having to follow hierarchical paths up and down, may improve the desire to excel. Pacific Gas & Electric's OPS MIS was confirmed by users of the system to be an example of the psychological benefit produced by ease of use. Another example of this psychological benefit factor follows: a utility instituted a process whereby all plant managers were required to list at the end of each week all the outages they had experienced, the remedy, the time it took to repair, access to spare parts and lost production. The computerized lists of *all* plants were circulated each Monday to management and *all* plant managers. Inefficiencies became visible and widely known very quickly and unit availability improved markedly.

1. Load forecast with respect to capacity (MW) and energy (GWh):

   - Economic forecasts of industrial activity
   - Archives of past load records (industrial, residential, . . .)
   - Weekly forecasts for the near term
   - Uncertainty range of all forecasts.

2. Generation resource availability:

   - Availability schedules of units under construction or rehabilitation
   - Technical parameters, e.g., maximum capacity of each unit, maintenance schedules of each unit (when, how long, how deferrable?)
   - Special case of the six Kozloduy nuclear units
   - Special case of hydro: snow pack and rain determines future capability
   - Air and other pollution restrictions
   - Import on the type of coal that may be burnt.

3. Transmission resource availability

   - See 2 above for same interactions.

4. Fuel planning:

   - Tentative generation schedules for the year
   - Tentative fuel purchase contracts
   - Iteration and optimization of generation schedules and fuel contracts.

5. Imports and exports:

   - Existing interchange contracts; terms[5]
   - Contracts under discussion; prognosis
   - Transmission limitations.

6. Assessment of major and long duration contingencies (e.g., Kozloduy unscheduled outage)

   - Listing of major contingencies; spare parts availability; repair crews
   - Reserve planning
   - Fuel reserves to cover contingencies
   - Hydro rescheduling potential (to mitigate a thermal outage)
   - Maintenance rescheduling potential

[5] The terms of Western interchange contracts may require complex documents. There are at least six generic interchange types, including emergency assistance contracts where no net energy is exchanged.

**TASK 8:** Assessment of the impact on the organizational structures within NEK. Analyze the staffing requirements (number as well as qualification of personnel) and the organization structure which matches the MIS. One would expect a much shorter hierarchy and a lot of lateral flow of information and decisions.

**TASK 9:** Selection of the best suited OPS MIS layout. Justification of the selected layout by considering cost, benefits, return on investment and "intangibles" such as personnel motivation.

## 3.6 REFERENCES


1. Terms of Reference: "Bulgaria Electricity Study — Medium- and Long-term Elements on Reorganization, Demand and Environment," US AID, January 31, 1992.

2. Technical Audit "Project for the Improvement of the Supervisory Control and Transmission Network System," Attachment to the IBRD Aide-Memoire of July 1992.

3. Draft Project for Financial Assistance "Energy Management System Development," no source, no date, Attributed to EnergoProekt with the help of Landis and Gyr in the last 24 months.

4. H. Wayne Hong, Carl F. Imperato, David L. Becker and James H. Malinowski, "Integrated Support Systems for Electric Utility Operations," IEEE Computer Applications in Power, January 1992.

5. Personal communication with Mr. Patrick Risen of Alcoa Fujikura; 105 West Park Drive, Suite, 100, Brentwood, TN 37027.

6. "Fiber Optics in Infrastructure Applications," First Pacific Networks, 601 W. California Ave., Sunnyvale, CA 94086.

### 3.5.2 Outline of the Statement of Work

An outline of the Statement of Work to be carried out in a Feasibility Study specifically aimed at NEK emerges from the background of this study.

TASK 1: Tabulation of the various functions performed within and outside of NEK that have a bearing upon operations. Development of a systematic format for summarizing these functions and indicating linkage with other functions. Examples are shown in Appendix A.

TASK 2: Listing of the operations planning functions that NEK is or should be carrying out. Coordination with EC consultant to ensure that the required functions will be performed within the most appropriate environment, either EMS or OPS MIS.

TASK 3: Relation of the OPS MIS implementation with EMS/SCADA implementation. Analyze:

- Option A: Separate implementations
- Option B: Integrated implementation
- Option C: Evolutionary implementation, beginning with A and moving toward B.

TASK 4: Relation of the OPS MIS with the larger NEK MIS. Listing of organizational interactions. Review of existing plans for a utility-wide MIS as well as isolated MIS pieces that already exist. Recommendations and action plan for the efficient implementation of the OPS MIS in the presence of these other existing or planned systems.

TASK 5: Determination of inter-utility communication requirements. Identify the communication requirements associated with the OPS MIS alternatives retained as serious contenders. Provide solutions that take into account the available communication technologies, including fiber optic and mobile, other unrelated communication uses (e.g., protections), opportunities for leasing excess capacity to recover part of the cost.

TASK 6: Analysis of the issues of integrity and access summarized above. Review of how other organizations handle these issues from the point of view of organization and technology.

TASK 7: Layout of alternative implementations. These layouts should specify the computer hardware, software, communication, and man-machine interfaces and be responsible to the OPS MIS action plan established in Task 4.

# 4.0 STRUCTURAL ALTERNATIVES

This chapter examines Bulgaria's alternatives for structuring its electricity subsector. It proposes a mission for the subsector, describes the approach to conducting the study, outlines the desirable attributes of a new structure and examines the implications of some critical constraints. The definition of structural alternatives along with a discusses their advantages and disadvantages and the identification of a subset of options for further consideration is included in Appendix D of this report. The chapter concludes with a presentation of a process to guide the evolution of the structure of the electricity subsector.

## 4.1 STUDY APPROACH

Our approach to this element of our task consisted of five distinct components, described below:

### 4.1.1 Preliminary Survey

This step consisted of a survey of the major organizational units that constitute the National Electric Company to develop a working knowledge of the company and its operations. Through the broad exposure to the company and its people, this step enabled us to obtain a sense of the strengths and weaknesses of the organization, including a sense of its internal culture. The results of this preliminary survey also provided the foundation for the observations, conclusions and recommendations presented in Chapter 2 of this report.

### 4.1.2 Strategic (Top-Down) Analysis

Strategy should be a major factor driving the basic architecture of an organization. The strategic organizational analysis should be performed first so that it can provide a context for the operational (bottom-up) feedback. Our approach to strategic organizational analysis consisted of four steps:

- Develop key attributes and criteria
- Identify the range of possible structural options
- Evaluate and refine grouping options
- Develop a short list of alternative structural options.

The ways in which these activities are connected will vary in some important ways depending on how the electricity subsector is structured. As used here, "structure" refe to the way the subsector is subdivided into one or more independently managed enterprises, to carry out the four basic activities identified above.

The **generation, transmission/central dispatch,** and **distribution** activities are primarily operational activities whose functions are generally understood. In contrast, the **supply** activity is less well understood because it is primarily a process of resource planning and project commitment, and thus is less visible than the physical operations activities. The supply activity assumes responsibility for procuring the resources needed to satisfy the future demand for electricity.

This consists of the following tasks:

- Forecasting demand for electricity
- Identifying supply-side options (generation and power purchases)
- Identifying demand-side options (conservation and load management)
- Developing resource plans combining the supply- and demand-side options
- Selecting the resource plan that represents the best balance of cost and risk
- Implementing the resource plan by constructing or acquiring the resources.

In addition to these tasks, the supply activity may include responsibility for some or all of the excess costs associated with forecasting errors and other unforeseen events leading to capacity surpluses and shortfalls.

- When the enterprise responsible for the supply activity assumes at least some of the risk for forecasting, planning, and procurement errors it has a strong incentive to conduct that activity in a manner that is likely to supply bulk power at "least cost."

There are a variety of structural configurations for the electricity subsector; each has advantages and disadvantages. The configurations are differentiated along two dimensions:

- Degree of vertical integration
- Degree of horizontal integration.

Each option needs to be assessed in terms of how well it supports the mission of the electricity subsector; thus, that mission must be explicitly defined. Ultimately, this mission statement will be defined by the COE, NEK and the Bulgarian Government. For this study, we adopted a variation of the predominant mission statement for electric companies in the West.

### 4.1.3 Operational (Bottom-Up) Feedback

This step consisted of several parallel activities. The core activities included a series of workshop sessions and review meetings with key representatives of the National Electric Company and the Committee of Energy. The purpose of these interactive sessions was to obtain feedback on the practical and operational considerations of the preliminary results of our strategic analysis. We also obtained feedback from other knowledgeable observers, including the World Bank, Central Maine Power Company and Arthur Andersen among others.

### 4.1.4 Synthesis

The objective of this step is to apply established knowledge regarding organizational design to integrate the results of the strategic and operational analysis, taking into account certain factors affecting the feasibility of the decision.

### 4.1.5 Implementation

The final phase is the implementation of organizational change. A common error in organizational planning is to assume that the work is complete once a new organizational structure has been identified. An organization redesign of any significance constitutes a major change and implementation issues are not trivial. Policies, methods, systems and reporting relationships will need to be altered. Individuals and groups have to be motivated to continue to perform and, in fact, to improve performance. In this phase, it is important to identify the key implementation issues, develop a plan and then execute that plan to ensure the objectives are achieved.

- The focus of this activity was the development of a process that can be followed to select and modify as appropriate a structure for the electricity sector.

- This implementation phase will be the responsibility of NEK and COE.

## 4.2 PERSPECTIVE: THE MISSION OF THE ELECTRICITY SUBSECTOR

The process of supplying electricity to consumers involves four major business processes:

- Generation
- Transmission/central dispatch
- Distribution
- Supply.

### 4.3.1 Economic and Financial Attributes

The structure of the electricity subsector should promote the efficient allocation and use of economic resources by:

- Producing electricity at least-cost
- Selling it under tariffs that provide cost-based price signals.

A structure that provides an enterprise with a profit incentive is likely to yield least-cost production. Similarly, a structure that encourages the setting of electricity prices reflecting the respective marginal costs of supplying customers will encourage those customers to make efficient use of the energy service. Finally, a structure that precludes the flow of financial subsidies to any enterprise will also preclude inefficiently low prices.

### 4.3.2 Managerial Attributes

To the extent practicable, the subsector structure should encourage decentralized management decision-making. Specifically, it should provide managers with control over the resources employed in the business activities for which they are responsible. The structure should also encourage innovative managerial techniques through appropriate risk-reward mechanisms.

### 4.3.3 Regulatory Attributes

The optimum subsector structure would obviate the need for economic regulation by substituting market competition. Because this is not possible in all of the enterprises or activities, the structure should allow forms of economic regulation that preclude enterprises with market power from exploiting that power through excessive prices or other undesirable behavior. It should also support regulation that promotes economically efficient and socially desirable management decisions with respect to safety, environmental and other societal needs. Finally, the structure should provide for a administratively simple regulatory scheme, to minimize the cost of the regulatory process.

## 4.4 KEY ASSUMPTIONS REGARDING STRUCTURAL ALTERNATIVES

Before conducting a top-down examination of specific structural options, we present a summary of key assumptions that are central to our evaluation of the efficacy of various structural alternatives. These assumptions are discussed in greater detail in Appendix D.

The proposed mission of Bulgaria's electricity subsector is:

> *to provide an adequate supply of electricity[1] at the lowest achievable cost consistent with safe, reliable and environmentally responsible operations that are in compliance with applicable laws and regulations and that serve the interests of stakeholders, including customers and employees while earning profits that are sufficient to achieve and maintain financial viability.*

This mission statement balances several conflicting factors. For example, electricity cannot be supplied with perfect reliability; as the reliability of supply increases, so does its cost. Also, complying with safety, environmental, regulatory and other societal requirements increases the cost of supplying electricity. But, if these requirements are properly developed, the resulting benefits to society will outweigh the additional cost of compliance. Subject to these constraints, the mission of the subsector should be to minimize the cost of supplying electricity to its customers.[2]

## 4.3 DESIRABLE STRUCTURAL ATTRIBUTES

In light of the mission statement presented above, a number of desirable attributes related to structure are readily identifiable. These can be grouped into three categories:

- Economic and financial
- Managerial
- Regulatory.

Each of these attributes is elaborated in the following sections.

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[1] The traditional mission statement of electric utilities was to provide "electricity" at least cost. In recent years, the trend in the West is to modify this mission to formally accord an equal role to conservation and demand-side management, resulting in a change to "electricity-related services". Lighting (and, specifically, high-efficiency lighting) is one example of an "electricity-related energy service". Nonetheless, we consider that a more traditional definition is in order for NEK, at least for the near future.

[2] Without subsidies, each enterprise must be self-financing, i.e., it must be sufficiently profitable to be able to raise the capital needed to fund operations and to invest in assets needed to support future growth. This does not imply that all of the capital must be internally generated from earnings; the enterprise's earnings need only be sufficient to attract capital from outside sources.

- Furthermore, an enterprise that is substantially owned by its management and employees should have even stronger incentives to be efficient than one owned solely by absentee shareholders.

- This is the essential argument in favor of privatization.[3]

### 4.4.3 Decentralized Decision-Making is Generally More Effective than Centralized Decision-Making

As a generalization, it is more effective to place decision-making authority close to the point of resource application, because the person closest to the point of application generally has the best available information regarding what is needed. However, this principle is only valid if the decisions involved will not significantly affect other units of the organization. If interactions do exist, some degree of centralized decision-making — or at least coordination — is needed. The merit order dispatch of generating plants is a good example of centralized decision-making.

Despite its greater effectiveness, decentralized decision-making authority may not always be as cost-efficient as centralized decision-making because it may not fully exploit economies of scale and scope. The tradeoff between the effectiveness of local control and efficiency of centralized control is well illustrated by the system of data-processing in organizations prior to the introduction of personal computers. During the 1960s and 1970s, corporate data-processing was generally done on mainframe computers by centralized data- processing departments. The managers of those departments typically implemented administrative systems and procedures designed to maximize the utilization of their computers, rather than to respond to the needs of the individual users. Although this approach reduced the per-unit cost of processing data, users (i.e., customers) were frequently dissatisfied with the quality of service they received.

[3] During the 1980s, government-owned electric utilities in the United States and Europe systematically overinvested in high-cost nuclear generating capacity relative to the needs of their markets. Although certain investor-owned (i.e. privatized) electric companies likewise overinvested in nuclear plant, the most egregious examples are among the government-owned utilities. Two of the most important reasons that investor-owned utilities took corrective action sooner were that (a) the profit motive caused managers to be more sensitive to increasing costs, and at an earlier stage than their counterparts in government owned utilities, and (b) there was an independent regulatory oversight of the privatized utilities. The reality is that effective regulation of government-owned utilities (i.e. by another entity) is more difficult to achieve than workable regulation of private enterprise.

### 4.4.1 Competition is Likely to Produce Economic Results Superior to those Produced by Regulation.

There are a number of reasons why decentralized decisions in a competitive marketplace are generally more effective than command-and-control decision-making. First, competition is likely to force costs down. Second, it is likely to result in prices that more closely reflect the respective costs of production. Third, it is likely to create services that are more responsive to customers' wants. Finally, it is likely to stimulate innovation in both technical and managerial areas.

- All of this typically occurs as a natural result of each competing supplier continually searching for ways to gain commercial advantage over its competitors.

- One important caveat to the argument favoring competition is that the size of the competing enterprises should be large enough to exhaust all, or most, of the economies of scale and scope associated with their specific activities.

- Ill-conceived economic regulation can force the privately-owned enterprise to pass all cost savings on to its customers, thereby nullifying any incentive to be efficient.

  - This is one of the criticisms of "cost-plus" regulatory methods.

Competition in the generation activity is where the largest payoff is likely to be. This is not only because multiple generation facilities are required, but also because generation accounts for such a large portion of the total cost of electric service, and because those costs are more controllable than are the costs associated with distribution.

### 4.4.2 Private Ownership is Likely to Provide Stronger Incentives for Production Efficiency than Public Ownership; It Also Offers Additional Sources of Capital

The key difference between private ownership and public ownership is that the former offers the potential for the enterprise to retain all of its cost savings. In contrast, even the best designed incentive schemes employed by publicly-owned entities typically allow the entity to retain only a small fraction of those savings. Because a privately-owned enterprise's management can justify paying its employees — and itself — bonuses out of savings, the incentives to perform can be made greater than in a publicly-owned enterprise.



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- A second disadvantage is that it discourages decentralized decision-making within an activity.

### 4.4.6 The Ability of an Enterprise to Raise Capital from External Sources is Influenced by its Market Power and its Size

Providers of equity and debt capital look to the certainty of an enterprise's future earnings potential as a critical test of the likelihood of not losing their invested capital. The profits of an enterprise that lacks effective competitors is highly assured, even if limited by some form of economic regulation. Regulators generally understand that their role is to limit profits to "fair" levels, not to put the regulated enterprise out of business.[4] Thus, because it provides an indispensable service, a transmission/central dispatch enterprise should have little difficulty raising the capital it needs.

- Generation enterprises operating in a competitive environment could have difficulties raising capital unless they have adequate long-term contracts with their buyers.
  - The construction of a new generating plant cannot be debt-financed unless it first has in place a power purchase agreement covering enough of its future output to assure its financial viability.
- Although a distribution enterprise will likewise be credit-worthy, at least as long as its customers lack reasonable alternatives to electric service, the amount of capital it can raise is limited.
  - For example, it is possible for an enterprise to grow so rapidly that it cannot debt-finance the new assets it needs to support its growth. This is less likely to be a problem for a horizontally integrated distribution system because the revenues from the low-growth areas can be used to finance the assets needed in the high-growth areas.

While size alone cannot make an enterprise credit-worthy, there are clear indications that financial institutions prefer making loans to larger enterprises, all else being equal. For this reason, horizontal and/or vertical integration tends to improve the ability of an enterprise to raise external capital.

[4] As evidence of this, consider that although more than 100 nuclear reactors under construction in the United States were cancelled at a cost of billions of dollars during the 1970s and 1980s, only two electric utilities were forced into bankruptcy, with (only) a few others left in dire financial straits.

### 4.4.4 Vertical Integration Offers Both Advantages and Disadvantages

The most important advantage of vertical integration is that it facilitates coordination among related economic activities, particularly the merit-order dispatch of generating plants. A second major advantage is that it allows the exploitation of economies of scale and scope through the sharing of common resources. Centralizing staff functions, such as financial management and personnel recruitment, are examples of this.

Integrated resource planning exploits both subsector-wide coordination and economies of scale and scope in centralized staffing. This planning process requires data about customers (which arise from the distribution activity) and data about current and future generation and transmission resources (which arise from the generation and transmission/central dispatch activities). The actual planning must be done by, or at least coordinated through, some central planning group.

Vertical integration encourages centralized decision-making, even when it is less effective than decentralized decision-making. There is a strong tendency in vertically integrated companies for management to attempt to direct every aspect of operations from the top.

- The greatest disadvantage of vertical integration is that it precludes the potential for competition among separate enterprises conducting similar activities.

Finally, vertical integration precludes the privatization of the generation and/or distribution enterprise(s) alone if it is decided that the transmission/central dispatch enterprise must remain in the public sector.

### 4.4.5 Horizontal Integration Offers Both Advantages and Disadvantages

The most important advantage of horizontal integration is that it allows the greatest potential for exploiting economies of scale and scope in the integrated activity. This is particularly important for the transmission/central dispatch activity.

A second advantage is that it offers management the option to average the costs of service across the distribution regions, thereby allowing uniform national pricing of electricity. Although such cost averaging may be undesirable from the perspective of economic efficiency, having the option to do so is a political advantage.

- The greatest disadvantage is that it prevents competition among activities that could otherwise be efficiently disaggregated horizontally.

that is most readily available in distribution. Likewise, information regarding the costs operating existing generation and constructing and operating new generation is readily available in generation. Finally, information on transmission costs and constraints, and forecasts of future trading opportunities with interconnected power systems, is most readily available in transmission/central dispatch. Thus, the essential supply activity is to collect all of this information and integrate it, in order to create alternate resource plans, evaluate those plans, choose one of them, and take responsibility for its implementation.

Resource planning and procurement can be conducted by either a single enterprise that centrally plans the resources of the subsector, or collectively by a number of enterprises operating in a competitive electricity market. Except for the unique electricity supply industry in England/Wales, all electric power systems employ some form of central planning approach to ensure the adequacy of electricity supply.

If Bulgaria centralizes the supply activity within the entity responsible for the transmission/central dispatch activity, the supply activity can be successfully accomplished by any of the structural models suggested for further consideration.

### 4.4.9 A Subsector Structure that Provides for a Natural and Orderly Transition from the Current State to the Ideal Long-Run State is Desirable

Bulgaria's electricity market is currently too small to support a spot market in electricity. We believe that the most viable forms of competition in generation will be limited to bidding for power purchase contracts covering new plants or renovations of existing plants, and capacity and economy energy purchases and sales with other power systems. Transactions with other systems will become increasingly important when Bulgaria becomes a member of a robust power pool.

One solution is to retain the integration of NEK's existing generation, transmission and distribution activities, but to mimic competitive market conditions through the implementation of the profit center concept and to acquire new generating capacity through competitive solicitations that leave the new additions in separate, privately-owned enterprises.

- This would introduce the concepts of independent power producers (IPPs) that were developed in the West and that have been proven in practice throughout the world into the Bulgarian electricity sector. Given the need for substantial sources of new capital, this option offers many attractive features.

This would capture the benefits of vertical integration with respect to existing generating plants while capturing the benefits of competition with respect to new generation. If

### 4.4.7 Economic Regulation That is Simple and Unintrusive is the Most Likely to be Effective

Several important lessons have emerged from decades of experience with economic regulation of electric power in the United States. First, regulatory systems that require regulators to examine in great detail an enterprise's financial performance and the decisions of its management are costly to administer. In addition, they can impose perverse incentives on management. Rate-base regulation, widely practiced in the United States, provides management with poor incentives to reduce costs and can provide strong incentives for inefficiency.[5]

Unfortunately, the economic regulation of generating enterprises has typically involved some form of intrusive, cost-based regulation because generation costs depend critically on fuel prices that can be volatile and uncertain. This is one reason why introducing competition into the generation activity is attractive. i.e., it eliminates the need for intrusive, cost-based regulation.

In contrast to generation, a distribution enterprise can be price regulated without necessitating detailed examinations of its costs, except perhaps once every five years or more. Prices charged for distribution services can be more easily are regulated using a scheme known as "RPI minus x."

In addition to distribution prices, the "RPI minus x" approach appears to be workable for regulating transmission prices; however, it is not capable of effectively regulating the transmission/central dispatch enterprise. That would require a more sophisticated vehicle that can provide incentives to encourage the enterprise to minimize the cost of supplying bulk power.

### 4.4.8 Bulgaria's Choice of Structure for the Electricity Subsector is Not Substantially Affected by Supply Planning Considerations

As described earlier, the supply activity consists of planning for and procuring the supply-side and demand-side resources needed to meet customers' future demand for electricity-related energy services. This resource-planning process generally involves not just the supply activity but the other three activities as well. For example, forecasting the demand for electricity and identifying options available for satisfying customer demand through conservation and load management requires information about retail customers

[5] In 1962, two economists published their hypothesis that, under rate-based regulation, utilities have an incentive to make uneconomic capital investments (i.e., to overinvest) in order to maximize the size of the rate base, and therefore the enterprise's profits. Named after is authors, this is known as the Averch-Johnson Theorem (AJT) effect.

Bulgaria should decide to privatize some or all of its existing power plants at some future time, the structure proposed should support that effort.

## 4.5 STRUCTURAL OPTIONS FOR FURTHER CONSIDERATION

The full range of options (identified as Options A through M) evaluated in the top-down portion of this study are discussed in greater detail in Appendix D. From this initial group, our analysis identified a total of five structural options that warrant further consideration. All of these options are shown schematically in Exhibit 4-1 and are described below. The structural options for further consideration can be divided into two groups. The first group consists of three basic structures.

### 4.5.1 Basic Structural Options

- An integrated generation, transmission/central dispatch and distribution company with one or more independent power producers (Option K).
- An integrated generation and transmission/central dispatch company with a separate, horizontally integrated distribution company and one or more independent power producers (Option L).
- An integrated generation and transmission/central dispatch company with multiple, separate, distribution companies and one or more independent power producers (Option M).

Highlights of these basic structures include the following:

- The transmission grid, including central dispatch, remain integrated with NEK's existing generation
- Independent power producers (IPPs) would be allowed to construct new power plants
- In two of the three structural options, the distribution branches would remain fully integrated

In addition, there are two other structural candidates that basically extend the structure to provide for the privatization of some or all of NEK's existing generation. These two variations were identified for further study as possible long-range structural options. The differences in these two are:

- Both options allow some or all existing generation to be spun-off from NEK and, presumably, privatized

- One option also provides the same potential for distribution operations.

### 4.5.2 Long-Term Variations

- An integrated transmission/central dispatch and distribution company with one or more independent power producers and also with existing NEK generation organized as separate and independent entities (Option D).

- An integrated transmission/central dispatch company with multiple, separate, distribution companies and one or more independent power producers and also with existing NEK generation organized as separate and independent entities (Option J).

### 4.5.3 Summary Assessment of Options for Further Consideration

The three options that would keep some or all of the existing generating plants vertically integrated with the transmission/central dispatch activity (Options K, L, and M) dominate all the others included in the initial analysis, except for the fully decentralized generation and distribution structure (Option J). In addition, Option D is a variation of Option K that results in a structure similar to Option J. The difference between Option D and Option K is that Option D allows for NEK's existing generation to be privatized.

- However, for these latter options to perform at the upper limit of the potential range, the electricity market must be large enough to allow most of the economies of scale and scope in generation to be captured, even with multiple competing enterprises.

- It is unclear that this condition is fulfilled in Bulgaria, particularly in light of its existing mix of generating plants. Still, these options should not be summarily dismissed.

This leaves a subset of the three basic options for serious study and further consideration. One attractive feature of these options (K, L, and M) is that they provide a good starting point from which the electricity subsector can evolve as the marketplace expands and grows in sophistication. NEK's existing generation could remain integrated with transmission/central dispatch and also the distribution branches. Later, after the marketplace has grown, individual power plants could be considered for privatization.

- The potential liability for physical injury and property damage in the even of an accident pose risks that may dictate continued government ownershi at least of the nuclear generation.

  - This may, in turn, oblige many of the remaining assets of the company to remain under government ownership.

- In addition to this exposure, there are enormous known and potential business risks associated with replacement power in the event of a forced outage due to an accident and the highly uncertain decommissioning costs for Kozloduy.

  - These risks cannot be fully insured and represent further reasons to maintain both government ownership and an integrated utility , at least for the foreseeable future.

- How and when the nuclear issues associated with the Kozloduy nuclear plant are resolved, will determine when — and perhaps whether — COE and NEK may implement certain of the structural options identified in this study.

- Important world banking representatives and certain members of the diplomatic community have expressed a strong preference for the utility to be maintained as a fully-integrated and state-owned monopoly.

  - Continued government ownership of the utility with, presumably easier, access to sovereign guarantees and the potential for some form of state funding, coupled with the blending of NEK's high-risk nuclear collateral with the lower risk non-nuclear collateral would provide a lower credit risk to suppliers of capital.

  - If the utility is maintained as a fully-integrated, state owned monopoly, it would also simplify the administration of loan(s) to the electricity subsector.

  - However, the price for this may be the primacy of political imperatives over economic decision-making, including the distinct possibility of political pressure for some form of state subsidy for the electric utility business

- In the longer run, these assumptions probably should be reexamined and reevaluated.

## 4.6 OPERATIONAL FEEDBACK

The selection of the "best fit" structure will involve some important pragmatic considerations. Three of the most important constraints that must be accommodated by the structure selected for Bulgaria's electricity subsector are that the structure must:

- Maximize efficiency and enable the company to become a low-cost provider
- Facilitate the raising of the substantial amounts of external capital required for the foreseeable future
- Provide the ability to manage the risks associated with NEK's nuclear power plant
  - The reality NEK must face is that the Kozloduy nuclear power plant is widely considered to be one of the unsafest of the nuclear plants operating in Europe.
  - Consequently, an important consideration relates to the perception afforded the new structure. Whatever structure is selected, it must give assurance and comfort to key constituencies (Western governments and major international lenders) that it provides acceptable (i.e., very high) assurance of being able to safely operate and maintain the plant.

The ability to satisfy these three constraints is critical to the acceptability of the structure selected. In fact, the overriding constraint is the business risk associated with the company's Kozloduy nuclear plant. If the structure adopted for the electricity subsector does not adequately deal with the nuclear issues it will affect the company's ability to raise external funds. Indeed, it is clear that if a structure that is deemed unacceptable (i.e., by the world banking community and those Western governments providing aid and financing to Bulgaria) is even seriously considered, it will likely invoke serious reaction. In this area, the structure must be perceived as satisfying the nuclear risk considerations.

- Given the scale of potential liability associated with nuclear operations, an independent and privatized nuclear generating company is inconceivable in Bulgaria at this time.
  - This could not even be accomplished as part of the privatization scheme implemented in the United Kingdom.

- Inadequate incentive mechanisms.

In addition, the private sector in Bulgaria suffers from an underdeveloped body of contract law and other commercial laws and regulations relevant to a market economy.

## 4.7 CONCLUSION

In this section we present our assessment of some important decision criteria, a summary conclusion regarding a recommended transition structure and process.

### 4.7.1 Decision Criteria

Any structural option selected needs to be tested against some basic decision criteria. In fact, these criteria can be applied to each stage of the evolution of the organization and structure. The criteria and our overall assessment are as follows:

- **Risk.** This requires a subjective judgment to weigh the expected gain against the risks associated with implementing any given alternative approach.

- **Economy of Effort.** What option will likely produce the greatest result for the least cost and the least disturbance of the organization?

- **Timing.** Does this decision need to be completed swiftly to impose a new vision? Or does it require a moderate pace to allow the organization to develop the new skills and habits necessary for success?

- **Limitation of Resources.** The most important of the resources to be considered are the human resources necessary to implement the decision, especially the limited time and capabilities of the collective organization to implement the changes effectively.

Our summary conclusion is that NEK needs to pursue a course of action with a high-probability of success. The organization is already dealing with a blizzard of changes and — here more so than in most situations — the simplest solution is likely to be the best. The human resources in the organization appear to be overextended in their efforts to cope with the many new requirements of transforming NEK into a competitive, market oriented organization. Given the scale of the new systems, procedures and management disciplines to be developed or implemented, we believe a moderate pace to restructuring would be appropriate.

- But, given NEK's financial condition, including its compelling need for capital as well as the need to develop its management skills, systems and organizational infrastructure, there may not be any alternative to some variation of this trade-off.

- After the company is "on its feet," the most important focus should be profitability and service quality. These will be best served by an organization design that reflects the lessons learned from the competitive market economies in the United States and Western Europe.

- However, until the nuclear issues are widely considered to be under more satisfactory control than at present, some form of continued governmental involvement appears to be unavoidable. This may take the form of guarantees of funding for decommissioning and other costs, the establishment of a legal limit on the utility's liability, or some form of regulation or government-backed insurance).

- Realistically though, government involvement probably means continued ownership of the utility either completely or partially.

▸ The central implication of these constraints is that, for the foreseeable future, NEK will not have a completely free hand to adopt the structural options identified in this study.

- Nonetheless, we believe it is useful to examine the possible options on a top-down basis. The insights provided by this exercise can be very useful in designing a structure that optimizes both the real world constraints and also makes best possible use of structure to produce an efficient, responsive and profitable electricity subsector.

▸ As described in the next section, there are still some possibilities available to NEK to achieve certain benefits of competition and privatization in the without disturbing the interests of international lenders.

In addition, there are several other important factors that were identified in obtaining bottom-up operational feedback that will have a bearing on the ultimate success of any restructuring of the electricity subsector in Bulgaria. These factors are that NEK suffers from:

▸ A lack of management decision-making skill and experience, appropriate to a market-oriented economy

- These would probably include such functions as: executive management, including policy setting and corporate planning, financing (including financial planning and analysis), capital expenditure evaluation, corporate accounting and budgeting, management training and development, personnel management (including compensation), labor relations, legal and regulatory relations.

- Certain other functions and activities could be centralized, although the reason for centralizing them would be to achieve economies of scale. Examples include: billing and collections, cash management, fuel procurement, design engineering and construction project management.

- With the exception of major capital expenditure programs and the negotiation of major contracts (e.g., for fuel supply), the operational management of power plants and sales distribution branches would be the responsibility of the local branch managers.

  - Profit center managers (i.e., branch managers) would, however, be responsible to operate within certain predetermined constraints and according to accepted operating practices. For example, each profit center would have its own budget, both for personnel, expenses and capital expenditures.

  - However, some appropriate and realistic incentives need to be developed too.

  - And if the corporate headquarters does not act in a responsible manner in approving resources for the profit center (e.g., funding for expenses and capital, etc.) at a level and in a manner that is consistent with the results expected of the profit center, then the system will not work effectively and it may fail.

All things considered, this approach seems to offer a relatively low-risk approach to developing a competitive, market-oriented organization.

## 4.8 IMPLEMENTATION

The final phase is the implementation of organizational change. A common error in organizational planning is to assume that the work is complete once the organizational charts have been drawn up. An organization redesign of any significance constitutes a major change. The questions of implementation are not trivial. Policies, methods, systems and reporting relationships need to be altered. Individuals and groups have to

**Action Plan** | **LEGAL DEPARTMENT** | **Exhibit B-18**

## RECOMMENDATION

Explore the possibility of consolidating more of these attorneys at the headquarters.

## MAJOR STEPS

- Catalogue the major responsibilities of attorneys located in the branches.
- Assess the extent to which these activities could be performed by a centralized legal staff.
- Determine whether there are any statutory requirements concerning the physical presence of lawyers to be on-site at the branches.
- Present the results to the Managing Board for a decision.
- If approved, develop an implementation plan.

## RESOURCES REQUIRED

- This study should be conducted by an internal team with technical advisory assistance from an outside expert.

## SCHEDULE

- Catalogue responsibilities and complete the assessment by October 15, 1993.
- Review results and decide on action by October 15, 1993.
- If yes, develop an implementation plan by December 31, 1993.

## ESTIMATED COSTS AND BENEFITS

- The incremental costs of concluding the study should be minimal.
- The cost of implementing the consolidation would require certain relocation costs.
- The benefits would include greater flexibility, the ability to specialize, and better cost control.

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be motivated to continue to perform in the face of major turbulence. Therefore, in this phase, it is important to identify the key implementation issues, develop a plan and then execute that plan to ensure the objectives are achieved.

- The focus of this activity is the development of a process that can be followed to select and modify as appropriate a structure for the electricity sector.

- This implementation phase will be the responsibility of NEK and COE.

The implementation process that we reviewed and discussed with COE and NEK follows consists of two major phases:

- **Phase I.** First, NEK should implement fundamental improvements in its management systems, procedures and practices and concurrently organize the company into profit centers under the holding company form of organization.

- **Phase II.** After the foundations have been laid to improve the results of operations, COE and NEK can then proceed to implement certain other structural changes to further enhance the competitiveness of the electricity subsector.

  - The steps in this process are described schematically in Exhibit 4-2a through 4-2d), following.

  - We have included only the phases involved in restructuring the generation side of the business, although this general approach could also be applied in distribution, if it is so decided.

- Certain aspects of Phase II could be accelerated if circumstances warrant it. Specifically, a small-scale IPP pilot program could be initiated as a vehicle to learn how to implement this technique later on a larger scale.

This represents a gradualist approach that will allow NEK's management to develop the organization's ability to compete more effectively in a market economy. These basic skills, tools and techniques will be enhanced by the implementation of profit centers in the power plant and distribution segments of the utility. Once accomplished, the organization will be better prepared to adapt to the next series of changes.

**Action Plan** | **PERSONNEL DEPARTMENT** | **Exhibit B-20**

## RECOMMENDATION

Implement a project to automate the company's personnel records.

## MAJOR STEPS

- Conduct a study to identify and catalogue the personnel information requirements.
- Develop a conceptual system design.
- Survey available software to determine if any software packages adequately satisfy the company's needs.
- Develop a proposed system solution for review with the Managing Board.
- Modify the recommendations as appropriate and develop an implementation plan.

## RESOURCES REQUIRED

- The study should be conducted by a specialist or firm with relevant expertise.
- Implementation will require information technology resources (hardware, software, and programming).

## SCHEDULE

- Conduct the initial study by September 30, 1993.
- Develop a conceptual system design by December 31, 1993.
- Survey available software packaging by March 31, 1994.
- Develop a proposed solution by June 30, 1994.
- Review the solution with the Managing Board by July 31, 1994.
- Modify, as appropriate, and develop an implementation plan by September 15, 1994.

## ESTIMATED COSTS AND BENEFITS

- The costs of conducting the studies and developing a proposed system solution should be moderate and perhaps should be combined as part of an overall systems needs assessment for NEK.
- Implementation costs cannot be determined at this time.
- The benefits would include more efficient use of personnel information.

| Action Plan | OFFICE OF THE PRESIDENT | Exhibit B-19 |
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**RECOMMENDATION**

Develop and implement an automated executive information system (EIS) to facilitate the monitoring of key orders of the Supervisory and Managing Boards.

**MAJOR STEPS**

- Conduct a survey of senior management to identify key elements of information that should be considered for inclusion in an EIS.
- Identify other performance indicators to be considered for inclusion.
- Develop a conceptual design for the EIS, including hardware and software requirements and information sources and flows.
- Review the design with senior management.
- Incorporate appropriate modifications to the system design based on feedback from senior management and develop an implementation plan and schedule.

**RESOURCES REQUIRED**

- This action should be done by a specialist or firm with expertise in accounting, management information, and computer technology.

**SCHEDULE**

- Conduct the user needs survey and develop a conceptual design by September 30, 1993.
- Complete review and modifications by November 15, 1993.
- Develop an implementation plan by December 31, 1993.

**ESTIMATED COSTS AND BENEFITS**

- The work related to the initial survey and conceptual design should be conducted by a specialist or firm with the appropriate skills. This would cost 1.0 to 1.5 million leva.
- The incremental hardware and software costs cannot be determined at this time.
- The benefits would include more informed decision making and improved monitoring of key indicators.

| Action Plan | PERSONNEL DEPARTMENT | Exhibit B-21 |
|---|---|---|

**RECOMMENDATION**

Consider expanding the scope of responsibilities of the Personnel Department.

**MAJOR STEPS**

- Conduct a study to survey the responsibility areas included in the human resources functions of a sample of leading western electric companies.
- Develop a preliminary proposed approach to expanding the responsibilities of the personnel department, including staffing and other resources required.
- Review the approach with the Managing Board.
- Modify the plan as appropriate and develop an implementation plan.

**RESOURCES REQUIRED**

- The initial study should be conducted by an internal team with technical advisory assistance from specialist or firm with relevant expertise.
- The principal resource required to expand the Personnel Department is trained and experienced staff.

**SCHEDULE**

- Conduct the initial study and develop a proposed expansion plan by September 30, 1993.
- Review with the Managing Board by October 31, 1993.
- Modify as appropriate and develop an implementation plan by December 31, 1993.

**ESTIMATED COSTS AND BENEFITS**

- The incremental cost of the initial study should be moderate.
- The cost of the additional staffing and other resources required cannot be determined at this time.
- The benefits will relate to better use of the company's human capital.

# C.0 BACKGROUND INFORMATION ON REGULATION OF THE ELECTRIC POWER SECTOR IN BULGARIA

This appendix is divided into five sections:

- Ministry of Environment
- Committee on the Use of Atomic Energy for Peaceful Purposes (CAE)
- Committee on Energy
- Bulgarian Energy Regulatory Agency
- Summary Outline of Draft Law for Generation, Transmission, and Destination of Electricity.

These five sections provide the background information, referenced in Chapter 5.0, that was used in preparing this report. Naturally, with the rapid changes occurring in Bulgaria's electricity sector, much of this information is obsolete; however, it is provided as a guide to the situation that was current at the time of the study.

## C.1 MINISTRY OF ENVIRONMENT

In 1991, Bulgaria's Parliament adopted a new environmental protection law providing policy direction and an overall framework for environmental protection. Previously, a law for the control of air and water pollution had been in effect for about 15 years. The new law also specifies sizes of penalties and fines for violations and provides for free information to be available to the public.

In response to this, the Ministry of Environment began preparation of regulations. It also began preparation of new draft laws relating to air pollution and conservation of water resources. Drafts have been prepared following consultation with other ministries and independent interests such as the Green Party. Extensive use of the clean air and water legislation and regulations of the United States was made in the drafting of this legislation.

In seeking to administer environmental protection legislation insofar as this relates to the power sector, the Ministry has focused on non-nuclear power, because nuclear power is primarily the concern of the Committee on the Use of Atomic Energy for Peaceful Purposes (CAE).[1]

[1] The Ministry of Environment does have responsibility and authority to monitor radiation effects of nuclear generation beyond 3 km from nuclear power plants. Radiation of groundwater may be monitored within the 3 km limit as well.

The 1991 legislation established norms for emissions from enterprises such as thermal power plants, differentiated as to type of fuel burned, caloric value, and size of plant. A power plants are covered. During the period up to the end of 1995, there is provision for liberal interpretation and considerable compromise with respect to the requirements. After 1995, all power plants will be expected to fully comply with the new standards.

An important task of the Ministry is enforcement of these standards through 16 regional inspection offices. Each of these offices monitors pollution caused by existing plants within its region, issues orders to correct violations, and can impose fines. It is mandatory that each new plant or piece of new equipment in existing plants fully reflect the standards in the design stage. Regulations specifying these standards have been issued and are being enforced.

If violations are found, the regional office seeks to resolve the issue through discussion with the plant (with NEK as observer). There is provision for exceptions and compromise in the imposition of fines and penalties; they can be reduced by the Ministry.

There is also provision for public participation in assessment of environmental impacts of new equipment on new plants proposed to be installed. Informal notice is given to affected municipalities and other interested groups regarding such proposals so the public can learn what is involved in upcoming negotiations.

New plants and rehabilitation of old plants require authorization from the Ministry of Environment. A letter of intent must be filed for any such proposal. This includes a section dealing with environmental impacts. If the Ministry staff are not fully competent to revaluate the environment impact, independent consultants are employed for this purpose. If the conclusion is negative, however, a public statement must be issued setting forth the reasons for rejection.

The Ministry also has substantial authority with respect to construction of transmission facilities. Proposals can be rejected on grounds of appearance or in cases in which a National Park would be impacted. Alternatively, the route may be changed by the Ministry. Various regulations have been issued, including one specifying minimum distances from buildings or other structures, and another requiring netting on high voltage lines to protect birds.

With regard to nuclear plants, Ministry authorization is required for any site to be used for storing nuclear waste material, whether inside or outside the 3 km radius from the plant; the concern here is primarily with water pollution. No procedures or standards have yet been established regarding decommissioning of nuclear plants.

## C.3 COMMITTEE ON ENERGY

In 1991, the Council of Ministers created the Committee of Energy (COE) with responsibility for oversight, policy analysis, and implementation for three industries: (1) electric power, (2) thermal power in the form of steam and hot water, and (3) coal mining. Among its primary responsibilities is assistance in developing pricing and other policies and methods of efficient utilization of electric power and other forms of energy. In addition, it engages in the promotion of research and development for electric energy, in supervision of investment activities, and in auditing. It also manages the fund from which subsidies are paid to cover out-of-pocket losses of individual companies.[2] While the COE is the owner of all property used by the companies engaged in electricity supply as well as supply of thermal energy and coal, it does not engage in the actual management or operation of these activities; that is the function of the different companies, such as the NEK, the district heating companies and the coal mining companies.

The COE is managed by its Chairman (or President), Deputy Chairman (or Vice President), and Chief Secretary. These have no fixed terms of office. Its staff consists of about 90 employees.

## C.4 BULGARIAN ENERGY REGULATORY AGENCY

### C.4.1 Creation of a Regulatory Agency

Concurrent with restructuring and privatization, a regulatory agency to be called the Bulgarian Energy Regulatory Agency (BERA) should be created, which could take the following form:

- Composition of BERA:
  - 3-5 Commissioners
  - Appointed by President and confirmed by the Parliament
  - Each Commissioner should have special expertise in one of the following:
    - Accounting/finance

[2] Sources of revenue for the fund are taxes and receipts from profitable energy companies.

Decisions by the Ministry of Environment can be appealed to the courts, but only on grounds that the decision is not in accordance with the law.

## C.2 COMMITTEE ON THE USE OF ATOMIC ENERGY FOR PEACEFUL PURPOSES (CAE)

The law making the CAE responsible for the safety of nuclear power plants was adopted in 1985. Members of the CAE include the Deputy Ministers of various ministries (such as the Ministry of Industry) along with scientists and others with knowledge of the nuclear field — currently a total of 18 people. This committee is summoned once or twice a year by the Chairman of the CAE, who presents his program to them, informs them of his activities, and receives their comments. Essentially, the committee serves as a sounding board for the Chairman, who appears to have full authority under the Council of Ministers (COM). Indeed, when matters relating to nuclear power are discussed by the COM, the Chairman of the CAE participates *ex officio* in the capacity of a First Deputy Minister.

The staff of the CAE consists of about 80 people, including 15 people on site at the Kozloduy plant. Staff divisions were created by law. The include a Division of Safety Inspections, which monitors and regulates the nuclear facilities. While this division has independent authority, it reports to the Chairman, who can overrule its directives. The R&D and Technical Coordination Division carries on research relating to nuclear safety and peaceful applications of nuclear energy such as medicine, etc. The International Division promotes diplomatic and political activity relating to nuclear energy, such as non-proliferation and technical assistance. Finally, the Crisis Center maintains direct communication with the nuclear plant and remains in close communication with civil defense authorities.

The CAE has full authority for licensing of nuclear facilities, including authority to condition licenses as it considers necessary. Currently, the license for the nuclear plant is issued only for a one-year period so that annual relicensing is required with opportunity to add conditions as necessary. Plant operators are required to be university engineers and to have their licenses renewed every two years.

The Chairman of the CAE has the authority to shut down particular nuclear units or the entire nuclear plant if he finds this necessary for the protection of health and safety, and in the past he has had occasion to do so. He can, however, be overruled by the COM. The law currently leads to much discussion rather than clearly setting forth the responsibilities of those who must assure that nuclear power does not adversely affect health and safety. Consequently, it appears that there is considerable room for improvement by way of clarification of responsibility and authority.

(9) Licensing thermal and electricity generation facilities other than nuclear.

(10) Dispute resolution.

### C.4.3 Design Features

- Autonomy and independence
  - A law should expressly set forth the powers and responsibilities of BERA
  - Fixed terms for Commissioners with protection against reassignment or other retribution for unpopular decisions
  - Authority and responsibility of BERA to prepare its own budget and present it directly to the Council of Ministers and to levy fees to cover its budget
  - Autonomous authority to hire, fire and promote staff.
- Accountability
  - Responsibility and authority of BERA defined and limited by statute with BERA decisions detailed in writing and subject to judicial challenge
  - Budget reviewed by the Council of Ministers and Parliament
  - Accounts audited by independent authority.
- Limited regulatory authority
  - Boundaries between BERA authority and the latitude given private entrepreneurs to act without regulatory oversight should be strictly defined and observed
- Division of regulatory responsibility
  - Not all regulatory functions affecting the companies specified in B(1) need be performed by BERA

- Economics
- Law
- Engineering.

- Terms of office:
  - Fixed five-year terms with possibility of reappointment
  - Staggered so that no more Commissioner positions than necessary are open per year.
- Commissioners and staff should be prohibited from owning any interest in any aspect of any industry regulated by BERA.
- BERA budget should be funded by user fees assessed on regulated entities (related to gross revenue) and subject to review/approval by the Council of Ministers.

### C.4.2 BERA Authority and Responsibilities

BERA authority and responsibilities include:

(1) Issuance of exclusive service franchises regarding: (a) electric transmission, dispatch and distribution, (b) district heating and gas distribution.

(2) Specification of service obligations of companies included in (1).

(3) Establishment of performance standards and monitoring of conformance thereto for companies included in (1).

(4) Approval of service codes developed by the companies included in (1).

(5) Enforcement of service obligations.

(6) Approval of rates, terms and conditions of service.

(7) Approval of investment and resource acquisition programs.

(8) Authorization of land use for transmission lines.

- Nuclear power licensing and monitoring could remain with the CAE
- Environmental regulation should remain with the Ministry of Environment.

► Public participation

- Rules governing public participation should allow interested parties an opportunity to provide comment and information, but would avoid administrative litigation in formal adjudicatory proceedings
- Will make regulatory actions more acceptable to the industry and the public
- Will improve the quality of regulatory decisions
- Must be structured to avoid unnecessary delay and conserve regulatory resources.

### C.4.4 Rate Regulation

► Objectives

- Protect consumers against excessive prices
- Provide sellers opportunity to recover costs of providing service including a sufficient return on equity to finance capital improvements and new construction
- Encourage efficiency by making the regulated company's return dependent on managerial success in controlling costs
- Assure accurate price signals regarding relative abundance or scarcity of supply.

► BERA will regulate rates for:

- Prices charged for transmission services, and pool pricing and dispatch services

## C.5 SUMMARY OUTLINE OF DRAFT LAW FOR GENERATION, TRANSMISSIC AND DESTINATION OF ELECTRICITY

### C.5.1 Authority and Responsibilities of the Council of Ministers

- The Council of Ministers acting through the Committee of Energy (COE)
  - Develops and applies national energy policy
  - Collects information necessary for this purpose
  - Promotes efficient production, transmission, distribution, and use o: electricity as well as cogeneration
  - Creates preferences for production from renewables
  - Plans, coordinates, finances and manages R&D
  - Creates conditions for competition in electric power industry
  - Protects consumers in regard to price and quality of electric service
  - Defends property and health of citizens from adverse effects of electricity production, transmission, and distribution
  - Enforces penalties
  - Other tasks as assigned by the Council of Ministers.
- COE assists responsible authorization in protection of environment
- Electric utility organization
  - Engages in production, transmission, or distribution for purpose of sale of electricity.
  - May be sole proprietor, commercial firm, association of firms, cooperatives, or municipality.
  - Small power stations (generation cap of 10 MW or less using renewable as primary sources) are *not* included. COE can change the 10 MW maximum value.

- Maintain necessary fuel reserves at power plants
- Operate or not operate plants or operate at specified output levels and with certain types of fuel
- Coordinate use of transmission facilities and allow use by small power plants.

- Emergency powers
- Eminent domain
- Rights of trespass
- A fund of stabilization of electric utilities is to be governed by COE (with fee schedule agreed by Ministry of Finance). Fund is financed by taxes anc fees for generating licenses, etc.

### C.5.2 Conditions for Supply of Electricity by Electric Utilities to Consumers

- Electric utility obligations:
  - To serve consumers
  - To buy from small power plants (SPP) under conditions set by COE
  - To provide auxiliary power to SPPs.
- Sensitive users (such as hospitals) must provide for alternative supply.
- Electric utility must supply energy under contract to large users (above 30 kW), subject to change by COE. Otherwise, power may be supplied under tariff.
- Contractual disputes are to be settled with assistance of COE.
- Force major.
- Electric utility's rights to disconnect:
  - Legitimate reasons for disconnect (customer does not pay on time, etc.)
  - Requires written order of the COE
  - Can be appealed to COE

- Council of Ministers controls prices of electric energy based on proposals by COE.

- Council of Ministers (based on proposals by COE and after coordination with local authorities) issues licenses to electric utilities for:

  - Production of electricity, or

  - Transmission and distribution within the limits of a region stated in the license.

- License may include:

  - Necessary conditions for implementation of state policy
  - Fee
  - Contract conditions between electric utilities
  - Provisions for change or cancellation.

- Council of Ministers can change or repeal a license when:

  - Interests of consumers are infringed or expected to be infringed
  - Regulations relating to state security are infringed
  - A violation of international contracts exist
  - There is a lack of technical possibility
  - A violation of anti-trust law exists
  - Conditions of license are changed or violated, or
  - New conditions emerge that require change of the license.

- If license is repealed, the electric utility can reapply only after a two-year period.

- COE can grant right to build, extend or renovate power plants and transmission facilities over 20 kV. Building of new facilities must be coordinated with Ministry of Environment.

- Decisions relating to licenses or rights to build, etc. may be appealed through provisions of administrative law.

- Export or import of electricity requires approval of Council of Ministers based on recommendations of COE.

- COE has authority to require electric utilities to:

# Appendix D

*Detailed Analysis of Structural Options*

- Supply must be restarted in two days after payment of the bill, etc.

### C.5.3 Control Over Generation, Transmission, and Distribution (GTD)

- Control lies with COE over:
  - Physical conditions and safety of electric utility assets
  - Price, quality and reliability of supply
  - Electric utility investment plans
  - Efficient GTD and use of electricity
  - Environmental policies
  - Other activities related to COE authority.
- Staff of COE have authority to:
  - Visit sites without restriction for purposes of inspection, etc.
- Staff of COE:
  - Obliged to investigate service complaints by users
  - Issue directives, within scope of competence, which are obligatory for execution.
- Authority of COE to obtain information from electric utilities, but must be kept confidential when it may create competitive advantage
  - Certain information, relating to indemnities paid to users and problems in supply and efficient GTD, to be supplied to COE by electric utilities annually.
  - COE is to make information public (presumably excepting confidential material).

## D.1 ASSUMPTIONS REGARDING STRUCTURAL ALTERNATIVES

In this section we present the full text of the key assumptions that are central to our evaluation of the efficacy of various structural alternatives.

### D.1.1 Competition is Likely to Produce Economic Results Superior to those Produced by Regulation

There are a number of reasons why decentralized decisions in a competitive marketplace are generally more effective than command-and-control decision-making. First, competition is likely to force costs down. Second, it is likely to result in prices that more closely reflect the respective costs of production. Third, it is likely to create services that are more responsive to customers' wants. Finally, it is likely to stimulate innovation in both technical and managerial areas. All of this typically occurs as a natural result of each competing supplier continually searching for ways to gain commercial advantage over its competitors.

One important caveat to the argument favoring competition is that the size of the competing enterprises should be large enough to exhaust all, or most, of the economies of scale and scope associated with their specific activities. If this is not the case, costs will be excessive for some, and possibly all, competitors, and prices could be unnecessarily high, even though competition exists. Eventually, the more successful enterprises will grow faster, gain cost advantages and bankrupt their weaker competitors. Although the problem may be "self-correcting," the "solution" may create a few enterprises with market power that could choose to collude. But even if the end result is an efficient, competitive market, the transition period can be disruptive and burdensome.

***Competition in Generation.*** Competition in the generation activity is where the largest payoff is likely to be. This is not only because multiple generation facilities are required, but also because generation accounts for such a large portion of the total cost of electric service, and because those costs are more controllable than are the costs associated with distribution. Done in the United States Studies suggest that economies of scale and scope in generation are largely exhausted for coal-fired generating stations consisting of at least four generating units (sets) in the range of about 400 to 500 MW each.

Competition among independent generation enterprises can occur in two forms, each of which involves different structural implications. The two forms are:

- Competition to sell into an hourly spot market for electricity, i.e., to get a particular generating unit included in the merit-order dispatch

power typically have been oversubscribed, often by substantial margins. Furthermore, the lowest bids are usually cheaper than the utility's "build-own-operate" alternative.

But competition need not be limited to procuring power from new capacity; existing generating capacity can also be forced to compete through the use of relatively short-term power purchase contracts that require frequent rebidding. Under this scenario, near the end of each contract period, each generation enterprise would be required to submit a schedule of capacity and energy charges covering each increment of capacity it is bidding. The supply enterprise would then determine the mix of contracts that would minimize the cost of providing electricity over the next contract period. Admittedly, this scheme would reduce the degree to which the competing generating enterprises could be debt-financed because lenders require the security of long-term contracts. Nonetheless, power plants operating under such short-term contracts could be privatized, as was demonstrated recently in the UK.[2]

Once a power purchase contract is signed, either from a new facility or from an existing one, there is no scope for competition until the contract expires. Thus, all of the benefits of the competition are captured "up front" in the pricing and other terms incorporated into the contract.

Bulgaria can exploit this form of competition today. Furthermore, doing so would not require that existing generation be separated from the transmission/central dispatch activity if competition were limited to purchases from new facilities. All that would be required would be to establish procedures for soliciting offers for power contracts and for evaluating the offers received. Once a contract is entered into, the electrical energy available under that contract could then be "dispatched" like any other generating unit.

***Competition in Transmission/Central Dispatch.*** Competition in the transmission/central dispatch activity is not practical in Bulgaria given the size of its electricity market. The economies of scale and scope for this activity are so large as to dictate that it remain horizontally integrated, thus precluding effective competition.

***Competition in Distribution.*** Competition among independent distribution enterprises can only occur in a limited form because it would not be not practical for them to compete

[2] Typically, private power projects are funded with 80% to 90% debt capital. This is possible only because most of the project's risk is shifted to the power purchaser through long-term contracts containing take-or-pay capacity payments. This ability to finance a project almost entirely with borrowed money makes it possible for small developers with little equity capital to participate, thereby broadening the competition. However, the cost incurred by society for the increased participation is that electricity prices will reflect their respective marginal costs of production as accurately as they would in an electricity spot market.

for the same customers through the use of duplicate facilities. For distribution enterprises that have exclusive retail franchises, competition can take the following fo:

- Competition for customers located near adjoining franchise areas
- Competition for skilled, experienced employees
- Competition through offering innovative services to customers
- "Yardstick" competition in which regulators compare the distribution cost of the enterprises under their jurisdiction.

Economies of scale and scope in distribution are an important consideration. Studies done in the Netherlands suggest that these economies are largely realized by distributio enterprises that have at least 300,000 to 400,000 connections. This implies that Bulgari: electricity market could support six or more distribution enterprises that would still be large enough to be economically efficient.

### D.1.2 Private Ownership is Likely to Provide Stronger Incentives for Production Efficiency than Public Ownership; It Also Offers Additional Sources of Capital

The key difference between private ownership and public ownership is that the former offers the potential for the enterprise to retain all of its cost savings.[3] In contrast, even the best designed incentive schemes employed by publicly-owned entities typically allow the entity to retain only a small fraction of those savings. Because a privately-owned enterprise's management can justify paying its employees — and itself — bonuses out of savings, the incentives to perform can be made greater than in a publicly-owned enterprise. Furthermore, an enterprise that is substantially owned by its management and employees should have even stronger incentives to be efficient than one owned solely by absentee shareholders. This is the essential argument in favor of privatization.[4]

[3] Ill-conceived economic regulation can force the privately-owned enterprise to pass all cost savings on to its customers, thereby nullifying any incentive to be efficient. This is one of the criticisms of "cost-plus" regulation methods.

[4] During the 1980s, many government-owned electric utilities in the United States and Europe systematically overinvested in high-cost nuclear generating capacity relative to the needs of their markets. Although certain investor-owned (i.e., privatized) electric companies likewise overinvested in nuclear plant, the most egregious examples are among the government-owned utilities. Two of the most important reasons that investor-owned utilities took corrective action sooner were that (a) the profit motive caused managers to be more sensitive to increasing costs, and at an earlier stage than their counterparts in government owned utilities, and (b) there was an independent regulatory oversight of the privatized utilities. The reality is that effective regulation of government-owned utilities (i.e. by another entity) is more difficult to achieve than workable regulation of private enterprise.

- Competition to sign a power purchase contract with the transmission gr or some other customer.

*Spot Power Market.* The most significant power market employing this form of competition today is in England and Wales. In that market, each generation enterpris bids a schedule of prices for delivering energy to the transmission grid the following d Generating resources are then centrally dispatched on the basis of these bid prices. E generator that is called to deliver energy to the grid in any half-hour is paid a price eq to the marginal (highest) price bid for that half-hour.

This pricing scheme provides strong incentives to reduce costs while also passing some the savings on to the electricity consumers, assuming there are enough competing generation enterprises that only own generating units running close to the margin. Thi is a very stringent condition; it requires a sufficiently large market for electricity to support the multiple generating units across the entire range of marginal costs, and also requires that those units be distributed among enough independent enterprises to make collusion very difficult. This condition is not currently satisfied anywhere in the world, including England and Wales. Today there exists no empirical data that can be u to judge the value of true spot market competition in electricity.

In addition to the need for multiple competitors having the "right" distribution of capacity, a spot market in power requires a sophisticated computer-based system for tracking the price bids (which change each day), dispatching plant in real time based on those prices, and settling the accounts of all the trading enterprises, i.e., the generation enterprises selling the power and the distribution enterprises and large customers buying that power.

- *Bulgaria's electricity market, along with its current mix of generating units, does not fulfill the stringent requirements for a spot power market and it is unlikely to do so for at least ten years.*

*Power Purchase Contracts.* The markets for power in the United States represent good examples of the competition involved in procuring power through purchased power contracts. In these markets, the benefits of competition are realized in the form of favorable contract terms covering purchases over many years. This type of competition has been most successful in terms of power to be purchased from newly constructed power plants, rather than from existing facilities.[1] Utility solicitations for purchased

[1] U.S. utilities have not had much experience with solicitations for private developers to renova nd operate an existing facility, but the process of doing so should not differ essentially from that of solic bids for a new plant. Actually, it should be simpler because the developer is spared the cost and risk having to site the plant, purchase rights-of-way for related infrastructure, and obtain environmental permitting.

### D.1.3 Decentralized Decision Making is Generally More Effective than Centralized Decision-Making

As a generalization, it is more effective to place decision-making authority close to the point of resource application, because the person closest to the point of application generally has the best available information regarding what is needed. However, this principle is only valid if the decisions involved will not significantly affect other units of the organization. If interactions do exist, some degree of centralized decision-making — or at least coordination — is needed. The merit order dispatch of generating plants is a good example of centralized decision-making.

Despite its greater effectiveness, decentralized decision-making authority may not be as cost-efficient as centralized decision-making because it may not fully exploit economies of scale and scope. The tradeoff between the effectiveness of local control and efficiency of centralized control is well illustrated by the system of data-processing in organizations prior to the introduction of personal computers. During the 1960s and 1970s, corporate data-processing was generally done on mainframe computers by centralized data-processing departments. The managers of those departments typically implemented administrative systems and procedures designed to maximize the utilization of their computers, rather than to respond to the needs of the individual users. Although this approach reduced the per-unit cost of processing data, users (i.e., customers) were frequently dissatisfied with the quality of service they received.

### D.1.4 Vertical Integration Offers Both Advantages and Disadvantages

The most important advantage of vertical integration is that it facilitates coordination among related economic activities, particularly the merit-order dispatch of generating plants. A second major advantage is that it allows the exploitation of economies of scale and scope through the sharing of common resources. Centralizing staff functions, such as financial management and personnel recruitment, are examples of this.

Integrated resource planning exploits both subsector-wide coordination and economies of scale and scope in centralized staffing. This planning process requires data about customers (which arise from the distribution activity) and data about current and future generation and transmission resources (which arise from the generation and transmission/central dispatch activities). The actual planning must be done by, or at least coordinated through, some central planning group.

Vertical integration encourages centralized decision-making, even when it is less effective than decentralized decision-making. Because top management has oversight on more activities, it will have a strong tendency to direct every aspect of operations from the top.

As important as it is, production efficiency is only one of the requirements for economic efficiency; the other is allocative efficiency, which requires that prices be reflective of their marginal costs of production. Although a privately-owned monopoly has a strong incentive to produce at minimum cost, it also has an incentive to set its prices too high. Thus, the ideal form of ownership for a "market power" enterprise necessarily depends on how effective regulatory incentives can be in encouraging economically efficient performance.

The network activities (transmission/central dispatch and distribution), clearly have market power, so they must be price-regulated if they are privatized. The distribution activity is relatively easy to regulate in ways that provide incentives for both production and allocative efficiency. "RPI minus x," a scheme employed in the United Kingdom has successfully done this. This scheme works as follows: the regulated enterprise is allowed to increase its prices each year by the general inflation rate, measured in the UK by the Retail Price Index (RPI), minus a predetermined amount (the "x" term). The x term is designed to account for the company's assumed productivity increase and to offer an incentive for efficiency improvement.

Regulation of the transmission/central dispatch activity poses a more difficult problem. The objectives of this activity should be to minimize the cost of providing bulk power to the distribution enterprises and to direct-sales customers, while also passing on most of the cost savings to the customers. In order to accomplish this, many complex and interrelated planning and operating decisions must be made every day. Examples include the central dispatch of available plant, coordination of generating plant maintenance scheduling, operation of pumped storage plants, and trading power with neighboring power systems. Developing and implementing incentive regulation to cover all of these activities is very difficult. For this reason, the transmission/central dispatch activity in Bulgaria probably should be left in the public sector until incentive regulation has been developed and proved to be effective.

In the UK, the transmission/central dispatch activity has been privatized, but its owners have virtually no control over it; control remains largely in the hands of the government. In the United States, transmission is mostly privatized, but only as part of vertically integrated enterprises, most of which are rate-base regulated. The efficacy of this regulatory approach is discussed next.

- The most important disadvantage of vertical integration is that it precludes the potential for competition among separate enterprises conducting similar activities.

Finally, vertical integration precludes the privatization of the generation and/or distribution enterprises if it is decided that the transmission/central dispatch enterprise must remain in the public sector.

### D.1.5 Horizontal Integration Offers Both Advantages and Disadvantages

The most important advantage of horizontal integration is that it allows the greatest potential for exploiting economies of scale and scope in the integrated activity. This is particularly important for the transmission/central dispatch activity.

A second advantage is that it offers management the option to average the costs of service across the distribution regions, thereby allowing uniform national pricing of electricity. Although such cost averaging may be undesirable from the perspective of economic efficiency, having the option to do so is a political advantage.

- The most important disadvantage of horizontal integration is that it precludes competition among activities that could otherwise be efficiently disaggregated horizontally.

- A second disadvantage is that it discourages decentralized decision-making within an activity.

### D.1.6 The Ability of an Enterprise to Raise Capital from External Sources is Influenced by its Market Power and its Size

Providers of both equity and debt capital look to the certainty of an enterprise's future earnings potential as a critical test of the likelihood of not losing their invested capital. The profits of an enterprise that lacks effective competitors is highly assured, even if limited by some form of economic regulation. Regulators generally understand that their role is to limit profits to "fair" levels, not to put the regulated enterprise out of business.[5] Thus, because it provides an indispensable service, a transmission/central dispatch enterprise should have little difficulty raising the capital it needs.

[5] As evidence of this, consider that although more than 100 nuclear reactors under construction in the United States were cancelled at a cost of billions of dollars during the 1970s and 80s, only two electric utilities were forced into bankruptcy, with (only) a few others left in dire financial straits.

Generation enterprises operating in a competitive environment could have difficulties raising capital unless they have adequate long-term contracts with their buyers. The construction of a new generating plant cannot be debt-financed unless it first has in p a power purchase agreement covering enough of its future output to assure its financi viability.

Although a distribution enterprise will likewise be credit-worthy, at least as long as its customers lack reasonable alternatives to electric service, the amount of capital it can raise is limited. For example, it is possible for an enterprise to grow so rapidly that it cannot debt-finance the new assets it needs to support its growth. This is less likely to a problem for a horizontally integrated distribution system because the revenues from i low-growth areas can be used to finance the assets needed in the high-growth areas.

While size alone cannot make an enterprise credit-worthy, there are clear indications th financial institutions prefer making loans to larger enterprises, all else being equal. For this reason, horizontal and/or vertical integration improves the ability of an enterprise tc raise capital externally.

### D.1.7 Economic Regulation That is Simple and Unintrusive is the Most Likely to be Effective

Several important lessons have emerged from decades of experience with economic regulation of electric power in the United States. First, regulatory systems that require regulators to examine in great detail an enterprise's financial performance and the decisions of its management are costly to administer. In addition, they frequently impose perverse incentives on the management. Rate-base regulation, widely practiced in the United States, provides management with poor incentives to reduce costs and can provide strong incentives for inefficiency.[6]

Unfortunately, the economic regulation of generating enterprises has typically involved some form of intrusive, cost-based regulation because generation costs depend critically on fuel prices that can be volatile and uncertain. This is one reason why introducing competition into the generation activity is attractive. i.e., it eliminates the need for intrusive, cost-based regulation.

In contrast to generation, a distribution enterprise can be price regulated without necessitating detailed examinations of its costs, except perhaps once every five to ten

[6] In 1962, two economists published a paper whose hypothesis is that under rate-based regulati utilities will have an incentive to make uneconomic capital investments in order to maximize the size of the rate base, and therefore the enterprise's profits. Named after is authors, this is known as the Averch-Johnson Theorem (AJT) effect.

by a privately-owned enterprise, their commonality of purpose provides a consistent framework for regulating the enterprise.

*Decentralized Supply Activity*. The alternative to a centralized supply activity is a competitive market that satisfies the demand for electricity through the decentralized decisions of individual supply enterprises, as is currently being attempted in England ar Wales. However, this approach requires the creation of a spot power market in which electric capacity and energy are freely traded in real time. Also, the supply enterprises must have free access to that spot market. Only the transmission/central dispatch activi can create this market because of its involvement in moving the energy from the seller the buyer (at least to the extent that it enters the grid at transmission voltage) and must have control over the output of the seller's generator.[7]

- The market-based approach in England and Wales has not yet produced enough empirical evidence to indicate how successful it will be. And since England and Wales currently have more excess generating capacity than they can utilize for at least 10 years, it is unlikely that much data will be forthcoming soon.

- In light of Bulgaria's lack of experience with market-based systems, and because of the stringent conditions required to support a competitive spot market in electricity, Bulgaria is unlikely to be well-served by a decentralized supply activity, at least in the foreseeable future.

Assuming that Bulgaria centralizes the supply activity within the entity responsible for the transmission/central dispatch activity, the supply activity can be successfully accomplished with equal ease by any of the structural models under consideration.

### D.1.9 A Subsector Structure that Provides for a Natural and Orderly Transition from the Current State to the Ideal Long-Run State is Desirable

As discussed above, Bulgaria's current electricity market is too small to support a spot market in electricity. We believe that the most viable forms of competition in generation will be limited to bidding for power purchase contracts covering new plants or renovations of existing plants, and capacity and economy energy purchases and sales with other power systems. Transactions with other systems will become increasingly important when Bulgaria becomes a member of a robust power pool.

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[7] The transmission/central dispatch activity must exercise control over the output of every generator to the transmission system to ensure the safe and stable operation of that system. Although it is not necessary to subject each of these generators to merit-order dispatch, it is highly desirable to do so because of the large potential cost savings.

years. Prices charged for distribution services can be more easily are regulated using a scheme known as "RPI minus x."

In addition to distribution prices, the "RPI minus x" approach appears to be workable for regulating transmission prices; however, it is not capable of effectively regulating the transmission/central dispatch enterprise. That would require a more sophisticated vehicle that can provide incentives to encourage the enterprise to minimize the cost of supplying bulk power.

### D.1.8 Bulgaria's Choice of Structure for the Electricity Subsector is Not Substantially Affected by Supply Planning Considerations

As described earlier, the supply activity consists of planning for and procuring the supply-side and demand-side resources needed to meet customers' future demand for electricity-related energy services. This resource-planning process generally involves not just the supply activity but the other three activities as well. For example, forecasting the demand for electricity and identifying options available for satisfying customer demand through conservation and load management requires information about retail customers that is most readily available in distribution. Likewise, information regarding the costs of operating existing generation and constructing and operating new generation is readily available in generation. Finally, information on transmission costs and constraints, and forecasts of future trading opportunities with interconnected power systems, is most readily available in transmission/central dispatch. Thus, the essential supply activity is to collect all of this information and integrate it, in order to create alternate resource plans, evaluate those plans, choose one of them, and take responsibility for its implementation.

Resource planning and procurement can be conducted by either a single enterprise that centrally plans the resources of the subsector, or collectively by a number of enterprises operating in a competitive electricity market. Except for the unique electricity supply industry in England/Wales, all electric power systems employ some form of central planning approach to ensure the adequacy of electricity supply.

*Centralized Supply Activity.* If the supply activity is to be centralized, the logical place for it is within the transmission/central dispatch enterprise because of that entity's interactions with both generation and distribution activities in directing the merit-order dispatch of generating plants. A second reason for co-locating the two activities is that both have similar and complementary objectives. The objective of the transmission/central dispatch activity is to operate the entire power system in a manner that minimizes the cost of supplying bulk power in the short-term (i.e., one year or less). The objective of the supply activity is to provide for a future system in a manner that minimizes the cost of supplying bulk power (and cost-effective demand-side substitutes for bulk power) over a longer time horizon. If these two activities are to be conducted

by a privately-owned enterprise, their commonality of purpose provides a consistent framework for regulating the enterprise.

*Decentralized Supply Activity.* The alternative to a centralized supply activity is a competitive market that satisfies the demand for electricity through the decentralized decisions of individual supply enterprises, as is currently being attempted in England ar Wales. However, this approach requires the creation of a spot power market in which electric capacity and energy are freely traded in real time. Also, the supply enterprises must have free access to that spot market. Only the transmission/central dispatch activ can create this market because of its involvement in moving the energy from the seller the buyer (at least to the extent that it enters the grid at transmission voltage) and mus have control over the output of the seller's generator.[7]

- The market-based approach in England and Wales has not yet produced enough empirical evidence to indicate how successful it will be. And since England and Wales currently have more excess generating capacity than they can utilize for at least 10 years, it is unlikely that much data will be forthcoming soon.

- In light of Bulgaria's lack of experience with market-based systems, and because of the stringent conditions required to support a competitive spot market in electricity, Bulgaria is unlikely to be well-served by a decentralized supply activity, at least in the foreseeable future.

Assuming that Bulgaria centralizes the supply activity within the entity responsible for the transmission/central dispatch activity, the supply activity can be successfully accomplished with equal ease by any of the structural models under consideration.

### D.1.9 A Subsector Structure that Provides for a Natural and Orderly Transition from the Current State to the Ideal Long-Run State is Desirable

As discussed above, Bulgaria's current electricity market is too small to support a spot market in electricity. We believe that the most viable forms of competition in generation will be limited to bidding for power purchase contracts covering new plants or renovations of existing plants, and capacity and economy energy purchases and sales with other power systems. Transactions with other systems will become increasingly important when Bulgaria becomes a member of a robust power pool.

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[7] The transmission/central dispatch activity must exercise control over the output of every generator to the transmission system to ensure the safe and stable operation of that system. Although it is not necessary to subject each of these generators to merit-order dispatch, it is highly desirable to do so because of the large potential cost savings.

One solution is to retain vertical integration between existing generation and transmission and to procure new generating capacity through competitive solicitations that leave the new additions in separate privately-owned enterprises. This would capture the benefits of vertical integration with respect to existing generating plants while capturing the benefits of competition with respect to new generation. If Bulgaria should decide to privatize some or all of its existing power plants at some future time, the structure proposed should support that effort.

## D.2 THE STRUCTURAL ALTERNATIVES

First, we describe the structural alternatives through variation of their respective degrees of vertical and horizontal integration.

- Option A: A Single, Vertically Integrated Enterprise
- Option B: Multiple, Vertically Integrated Enterprises
- Option C: A Single Generation Enterprise and a Separate, Integrated Transmission and Distribution Enterprise
- Option D: Multiple Generation Enterprises with an Integrated Transmission and Distribution Enterprise
- Option E: A Single Distribution Enterprise with a Separate, Integrated Generation and Transmission Enterprise
- Option F: Multiple Distribution Enterprises with a Single, Integrated Generation and Transmission Enterprise
- Option G: A Single Generation Enterprise with a Single Transmission Enterprise and a Single Distribution Enterprise
- Option H: Multiple Generation Enterprises with a Single Transmission Enterprise and a Single Distribution Enterprise
- Option I: Multiple Generation Enterprises with a Single Transmission Enterprise and Multiple Distribution Enterprises
- Option J: Multiple Generation and Distribution Enterprises with a Single Transmission Enterprise.

In addition to the ten "pure" options, there are three additional "hybrid" options that vertically integrate some generation in the transmission enterprise. These are variants of Options D, H and J.

- Option K: Multiple, Independent Generation Enterprises along with an Integrated Generation, Transmission and Distribution Enterprise
- Option L: Multiple Generation Enterprises with an Integrated Generation and Transmission Enterprise and a Separate, Self-Contained Distribution Enterprise
- Option M: Multiple Generation and Distribution Enterprises along with a Self-Contained Generation and Transmission Enterprise

## D.3 ASSESSMENT OF THE STRUCTURAL ALTERNATIVES

The relative advantages and disadvantages of each of the structural alternatives ident in the previous section are discussed here. Exhibit 4-2 summarizes the results.

**Option A: A Single, Vertically Integrated Enterprise**

This structural model is in widespread use throughout the world. Electricité de France (EdF) is representative of the publicly-owned enterprise for an entire country; the major investor-owned U.S. utilities are representative of the privately-owned version within a legally determined franchise territory.

The primary advantages of this option are its ability to fully exploit economies of scale and scope in all activities, to closely coordinate all operations, and to facilitate the raising of investment capital from external sources. In addition, it enables uniform national retail tariffs through internal cross-subsidization of the high-cost regions.

The primary disadvantage of this option is that it precludes competition in generation and distribution. Because of the lack of competition, the generation activity must be regulated in great detail to ensure that only "prudently incurred" costs are recovered through electricity prices. This option also precludes the privatization of generation or distribution unless the entire subsector is privatized as a whole. Finally, vertical integration fosters centralized decision-making with its associated disadvantages.

**Option B: Multiple, Vertically Integrated Enterprises**

Horizontally disaggregating Option A (the EdF Model) yields multiple enterprises that are essentially clones of the parent. This structure is represented by the large, regional electric utilities in the United States and Germany.

The power market in Bulgaria is too small for this structure, which would not fully exploit the economies of scale and scope in the transmission/central dispatch activity and not the generation activity either. It would also greatly complicate the coordination of merit-order dispatch of generating plants. Finally, it would almost certainly yield regionally differentiated electricity prices, as it does in the United States. This may be deemed socially unacceptable and politically inadvisable at present.

**Option C: A Single Generation Enterprise and a Separate, Integrated Transmission and Distribution Enterprise**

Vertically separating the generation activity from a combined transmission/central dispatch/distribution enterprise results in this option. We know of no country that has structured its electricity subsector in this way.

The main advantage this structure offers over Option A is that it allows the generation enterprise to be privatized even if the transmission grid remains in the public sector. Private generation is likely to be more efficient even if it is non-competitive. A second advantage is that it encourages decentralized decision-making by separating the subsector into two independently managed entities.

The main disadvantages of this structure are that it does not exploit economies of scale and scope offered by centralizing corporate staff functions, and it complicates the merit-order dispatch of generation plant.

**Option D: Multiple Generation Enterprises with an Integrated Transmission and Distribution Enterprise**

This option represents the only configuration that horizontally disaggregates the generation activity, but leaves the transmission/central dispatch and distribution activities combined. We know of no country that has structured its electricity subsector in this way.

Unlike Option A, this option offers the potential for competition among the generation enterprises, thereby promoting greater economic efficiency and reducing and perhaps eliminating the need for regulation. Because a spot power market is not feasible in Bulgaria today, such competition can only occur in the process of negotiating power purchase contracts. This option also allows the generation activity to be privatized, even

if the remainder of the subsector remains publicly-owned. Finally, it encourages decentralized decision-making in the generation activity.

On the negative side, like Option C, this option does not fully exploit economies of scale and scope offered by centralized staff functions, and it complicates the merit-order dispatch of generating plants. In addition, because of the competitive nature of the business and the smaller sizes of the individual generation enterprises, raising capital externally could be difficult for them if long-term power purchase contracts are not available from the transmission/distribution enterprise. Finally, this option could sacrifice economies of scale and scope in generation if the generation activity is fragmented into too many small entities.

**Option E: A Single Distribution Enterprise with a Separate, Integrated Generation and Transmission Enterprise**

Vertically disaggregating Option A into one generation/transmission/central dispatch enterprise along with a separate distribution enterprise yields this option. We know of no country that has structured its electricity subsector in this way.

The primary advantage that this structure offers over Option A is that it allows the distribution enterprise to be privatized while keeping the transmission/central dispatch activity in the public sector. Privatization offers incentives for improved economic efficiency. This option also encourages decentralized decision-making to a limited degree by creating separate enterprises.

The disadvantage of this option is that it would duplicate some corporate functions that could be performed by the headquarters staff of a single, vertically integrated enterprise.

**Option F: Multiple Distribution Enterprises with a Single, Integrated Generation and Transmission Enterprise**

Option F represents the only way to disaggregate distribution while keeping generation and transmission combined in the same enterprise. This structure is similar to the one employed by the "old" (pre-1990) England/Wales electricity supply industry in which the CEGB owned and operated virtually all of the generation and transmission plants.

The most important advantages of this option are that it allows competition (albeit limited) among the distribution companies, and also allows the distribution entities to be privatized even if the generation/transmission/central dispatch activities are not. It also encourages decentralized decision-making, to a limited degree, by creating separate enterprises.

The main disadvantage of Option F is that some distribution entities may have difficulty raising capital externally if their rate of growth is very high and economic regulation limits their ability to increase prices. In addition, the distribution entities will not fully exploit the economies of scale and scope offered by centralizing corporate staff functions and may not exploit those economies with respect to the distribution activity if too many small distribution entities are created. Finally, a disaggregated distribution activity makes uniform national retail tariffs difficult to sustain.

**Option G: A Single Generation Enterprise with a Single Transmission Enterprise and a Single Distribution Enterprise**

Vertically disaggregating into separate generation, transmission/central dispatch, and distribution enterprises results in this structure. We know of no country that has structured its electricity subsector in this way.

The advantages of this structure over Option A are that it allows the generation and distribution enterprises to be privatized even if the transmission/central dispatch entity remains in the public sector, and it encourages decentralized management decision-making.

The main disadvantages of this structure are that it does not exploit economies of scale and scope offered by centralizing corporate staff functions, and it complicates the merit-order dispatch of generation plant. Neither of these are serious defects.

**Option H: Multiple Generation Enterprises with a Single Transmission Enterprise and a Single Distribution Enterprise**

This is identical to Option G except that generation is disaggregated. We know of no country that has structured its industry in this way.

The main advantage of this structure is that it allows competition in generation. It also offers all of the advantages of Option G.

The main disadvantage of this option, in addition to those of Option G, is that it could increase the difficulty of the generation activity to raise capital from outside sources if long-term contracts are not employed.

**Option I: Multiple Generation Enterprises with a Single Transmission Enterprise and Multiple Distribution Enterprises**

This option is identical to Option G except that distribution is disaggregated. We know of no country that has structured its industry in this way.



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This option offers all of the advantages of Option G but also allows competition in distribution.

In addition to the disadvantages of Option G and H, the existence of multiple distribution entities precludes the use of uniform national retail tariffs.

**Option J: Multiple Generation and Distribution Enterprises with a Single Transmission Enterprise**

This option is identical to Option G except that generation and distribution are disaggregated. This is the structure adopted in the recently privatized England and Wales electricity supply industry.

The main advantage of this structure over Option A is that it allows competition and privatization for both generation and distribution. Because generation is competitive, the need for price-regulation is greatly reduced. This structure provides the maximum opportunity for decentralized management decision-making.

This option has a number of disadvantages. First, it does not fully exploit economies of scale and scope in corporate staff functions, and possibly in generation as well, depending on the degree of fragmentation of this activity. Merit-order dispatch of generating plants is also complicated by this fragmentation. Third, the generation entities may have difficulty raising capital externally if long-term contracts for their power sales are not available. To a lesser extent, the distribution entities could also experience financing difficulties, depending on how rapidly their service areas are expanding. Finally, this structure precludes the use of uniform national retail tariffs.

**Option K: Multiple, Independent Generation Enterprises along with an Integrated Generation, Transmission and Distribution Enterprise**

This is essentially Option A with some or all new generation procured through power purchase contracts, and possibly some existing generation taken off and privatized. This structure reflects what is happening in the United States today. In response to pressure from regulators, many of the large vertically integrated electric utilities have decided to obtain all new generating capacity through competitive power purchase contracts. As time passes, the structures of these utilities will approach that of Option D.

This structure offers all of the advantages of Option A while also providing for an orderly pathway to privatized, competitive generation.

- For Bulgaria, one disadvantage of Option K is that legal structures for power contracting must be developed. In addition, Bulgaria's financial markets may require further development before private sources of capital of the size required can be mobilized.

**Option L: Multiple Generation Enterprises with an Integrated Generation and Transmission Enterprise and a Separate, Self-Contained Distribution Enterprise**

Option L is the same as Option K except that the distribution activity is conducted by a separate entity. We know of no countries that have structured their electricity subsector in this manner.

This structure shares the advantages of Option K while also allowing distribution to be privatized even if the transmission/central dispatch activity is not.

The disadvantage of this option, relative to Option K, is that it further duplicates some corporate staff functions.

**Option M: Multiple Generation and Distribution Enterprises along with a Self-Contained Generation and Transmission Enterprise**

This is the same as Option L except that the distribution activity is divided among a number of separate entities. This structure is employed in Sweden today.

This option shares the advantages of Option L while also allowing competition in the distribution activity.

The disadvantages of this option, relative to Option M, are that it may not fully exploit economies of scale and scope in distribution and that some distribution entities could experience difficulties in raising capital externally. Also, this option precludes the use of uniform national retail tariffs.

## D.4 CONCLUSIONS

This final section presents comparisons regarding the relative attractiveness of the various structural alternatives for Bulgaria. Although no single structure appears to be optimal for Bulgaria, a subset of options appear to be superior to the others.

**Option A: A Single, Vertically Integrated Enterprise**

Because of its widespread use, Option A (the EdF model) has been adopted as the benchmark in this comparative analysis of alternatives.

**Option B: Multiple, Vertically Integrated Enterprises**

Because of the relatively small size of the Bulgarian electricity market, this option is clearly inferior to Option A and need not be considered further.

**Option C: A Single Generation Enterprise and a Separate, Integrated Transmission and Distribution Enterprise**

This option is superior to Option A only if Bulgaria decides to keep the transmission/central dispatch and/or the distribution activities in the public sector. On the other hand, if the entire electricity subsector is to be privatized, Option C is inferior to Option A because of the higher costs associated with duplicate corporate staff functions.

**Option D: Multiple Generation Enterprises with an Integrated Transmission and Distribution Enterprise**

It is not clear whether Option D is better or worse than Option A. Horizontally disaggregating the generation activity to the extent that economies of scale and scope are lost would increase costs. At the same time, the benefits of vigorous competition would require a sufficient number of independent generating enterprises to be created. This dilemma cannot be resolved without conducting a detailed study of each generating unit's costa of power production. Relative to the competition and economies of scale and scope issues, the advantage of decentralized decision-making is a minor consideration. However, technical and regulatory considerations may be relevant, such as separating nuclear and conventional generation.

**Option E: A Single Distribution Enterprise with a Separate, Integrated Generation and Transmission Enterprise**

This option is likely to be superior to Option A because the increase in efficiency potentially resulting from private ownership is likely to exceed the relatively small added costs of duplicating some corporate staff functions. However, it is difficult to quantify the magnitude of the net gain.

**Option F: Multiple Distribution Enterprises with a Single, Integrated Generation and Transmission Enterprise**

This option is arguably superior to Option E and thus to Option A as well. In addition to the advantages of Option E, it offers the benefits of competition among the distribution enterprises. Although the disaggregation of the distribution activity could result in economies of scale and scope being lost, there is convincing evidence that the Bulgarian electricity market is large enough to support multiple distribution entities that largely exhaust those economies. Similarly, the value of uniform national tariffs is political, but it reduces economic efficiency. If the tariffs were to accurately reflect regional differences in the costs of distribution, those differences would most likely be proportionately small because generation and transmission costs account for most of the total. Thus, the real tradeoff between this option and option E is between the benefits of competition in distribution and the potential problem of financing difficulties faced by fast growing distribution enterprises.

**Option G: A Single Generation Enterprise with a Single Transmission Enterprise and a Single Distribution Enterprise**

This option is superior to Option E and thus to Option A as well. Whether it is better or worse than Option F depends on the relative advantage of privatization of the generation activity (without competition) vs. competition within the distribution activity. Also, Option G creates more duplication of corporate staff functions than Option F, but may provide better financing for the single distribution enterprise and makes uniform national tariffs easier to implement.

**Option H: Multiple Generation Enterprises with a Single Transmission Enterprise and a Single Distribution Enterprise**

Although it is undetermined, this option should be superior to Option G for the same reason presented immediately above, i.e., the favorable expected tradeoff between the benefits of competition and the possibility of losing economies of scale and scope. What is reasonably clear is that this option is superior to Option D for the same reasons that Option E is superior to Option A, i.e., the improved efficiency of private ownership of

the distribution activity vs. the higher cost of duplicating corporate staff functions in the distribution entity.

**Option I: Multiple Generation Enterprises with a Single Transmission Enterprise and Multiple Distribution Enterprises**

This option is likely to be superior to Option G for the same reasons that Option F appears to be superior to Option A, i.e., the benefits of competition in distribution should outweigh the disadvantages of potential financing difficulties and the loss of uniform national retail tariffs.

**Option J: Multiple Generation and Distribution Enterprises with a Single Transmission Enterprise**

It is not clear whether this option is better or worse than Option A for the same reasons that the comparison between Option D and Option A is ambiguous. However, this option is likely to be superior to Option D, primarily because the distribution activity can be privatized even if the transmission/central dispatch activity is not.

**Option K: Multiple, Independent Generation Enterprises along with an Integrated Generation, Transmission and Distribution Enterprise**

Option K is clearly superior to Option A and also to Option D. It offers a structure that can retain all of the economies of scale and scope in generation while also gaining the benefits of competition to the extent they exist. In addition to competitively procuring all new generating capacity from outside enterprises, the existing power plants (or groups of power plants) that can be economically operated as separate enterprises can be separated off and privatized. The other existing power plants (e.g., Kozloduy) can remain integrated with the transmission/distribution enterprise. This option offers maximum flexibility for restructuring the generation activity.

**Option L: Multiple Generation Enterprises with an Integrated Generation and Transmission Enterprise and a Separate, Self-Contained Distribution Enterprise**

This option is superior to Option A, and probably to Option K as well, for the same reasons that Option E is probably superior to Option A.

**Option M: Multiple Generation and Distribution Enterprises along with a Self-Contained Generation and Transmission Enterprise**

This option is superior to Option A, and appears to be superior to Option L for the same reasons that Option F is superior to Option E.

# BULGARIA DEMAND SIDE MANAGEMENT ASSESSMENT

Final Report

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# BULGARIA DEMAND SIDE MANAGEMENT ASSESSMENT

Final Report

*Prepared for:*

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# EXECUTIVE SUMMARY

## S.1 INTRODUCTION (Please refer to Chapter 1 for more details)

### S.1.1 Project Overview

This report presents partial results of work performed as part of the energy sector assistance provided to Bulgaria by the U.S. Agency for International Development. It was prepared as part of Task 1 - Electricity Sector Study and Action Plan, in coordination with the European Community, by RCG/Hagler, Bailly, Inc. The report investigates opportunities to improve management of demand, through a demand-side management (DSM) program.

### S.1.2 Background and Recent History of Electricity Demand

Beginning in 1990, the Bulgarian economy went into severe recession. Production decreased from most factories, traditional markets and trading partners were lost, centralized production structures were dismantled, state subsidies were cut drastically, prices increased, and unemployment grew rapidly. During this period, Bulgaria was faced with particularly acute energy problems, including power outages.

Total consumers' electric energy demand in Bulgaria in 1992 was 25% less than the maximum recorded in 1988. Reductions in annual energy sales (comparing 1992 with 1988) were 34% for industrial, 4% for households (no real price increases occurred in this sector until 1991), and 28% for other consumers (agriculture, transportation, public buildings). Analysis of the load duration curves reveals that most of the reduction in demand has occurred during summer months, and that some reduction has occurred during off-peak periods in the winter.

Peak power demand (absolute maximum gross MW recorded during the year) has reduced less than energy demand, and is now 15% less than the maximum recorded in 1989. During 1991 (the base year for this study), the maximum was recorded in January (7,500 MW), and August experienced the lowest peak (4,300 MW).

## S.2 RESULTS OF INDUSTRIAL ENERGY SURVEY AND ENERGY AUDITS (Please refer to Chapter 2 for more details)

### S.2.1 Industrial Energy Survey

A survey of the NEK's 106 largest electrical consumers was commissioned by Hagler, Bailly and carried out by Dimitar Baev - DBC, a Bulgarian firm. Sixty-one firms responded to the basic survey, 35 of which responded to more detailed follow-up questions. The survey included questions on business and operating conditions, current and projected electricity usage, installed equipment for electricity generation and use, and energy conservation.

In general, the survey responses reflected the dire economic conditions and the need to find new markets. However, on balance it seems that these plants may have reached the bottom, with 1993 production and electricity usage not expected to decline much further.

According to NEK, Bulgaria now has nine large industrial cogenerators (with capacities of 20 MW or greater). Six of the 61 plants surveyed can generate their own electricity, but the survey discovered that two of these do not operate their generators regularly.

Electric motors and lighting are the dominant loads in the plants surveyed, and less than half have installed efficient lighting systems (such as high pressure sodium). Process loads are significant in the chemicals and metals industries for electrolysis, heat treatment, furnaces, and rolling mills.

Most plants surveyed are interested in energy conservation, and are willing to invest in such projects. Most have ideas for projects, but have not implemented them for lack of funds or for fear that they might disrupt production. Energy audits have been conducted in half the enterprises, but respondents indicated problems with the quality of the energy audits.

### S.2.2 Industrial Energy Audits in Bulgaria

Under funding provided by the USAID Emergency Energy Project, energy audits were carried out in eight industrial enterprises in Bulgaria in 1991 by International Resources Group (IRG) of Washington DC. These audits revealed that substantial opportunities exist to improve energy efficiency. Problems were identified in many areas, including management, instrumentation, motivation, training, communications, organization, financing, accountability, and investment decision-making. The audits recommended that focus be placed on short-term, low-cost measures.

Hagler, Bailly's experience in energy audits in other countries in eastern Europe, together with experience in Bulgaria conducting the Industrial Energy Efficiency project since 1992, was used to develop a list of candidate measures for electric energy efficiency.

## S.3 DEMAND FORECAST (Please refer to Chapter 3 for more details)

### S.3.1 Review of Previous Forecasts of Electricity Demand

Several forecasts of electricity demand in Bulgaria have been completed over the past several years. Prior forecasts differ because of differences in scenarios, differences in forecasting techniques, and differences in data. However, the more recent forecasts that build on the data obtained after the initiation of Bulgaria's transition to a market economy will more accurately capture the Bulgarian economy's energy response to this transition and the probable future of electricity demand.

The forecasts are summarized graphically in Exhibit S-1, and listed below.

- Forecast by NEK, the guidance from the World Bank, in 1992, with three variants:
  - -- most likely scenario
  - -- high demand scenario
  - -- low demand scenario
- Forecast by Equipe Cousteau for the EBRD in 1992
- Forecast by Prof. Gordon Hughes for the World Bank in 1991
- Energoproekt forecast 1991 (high and low demand scenarios)
- Forecast by Hagler Bailly in 1993

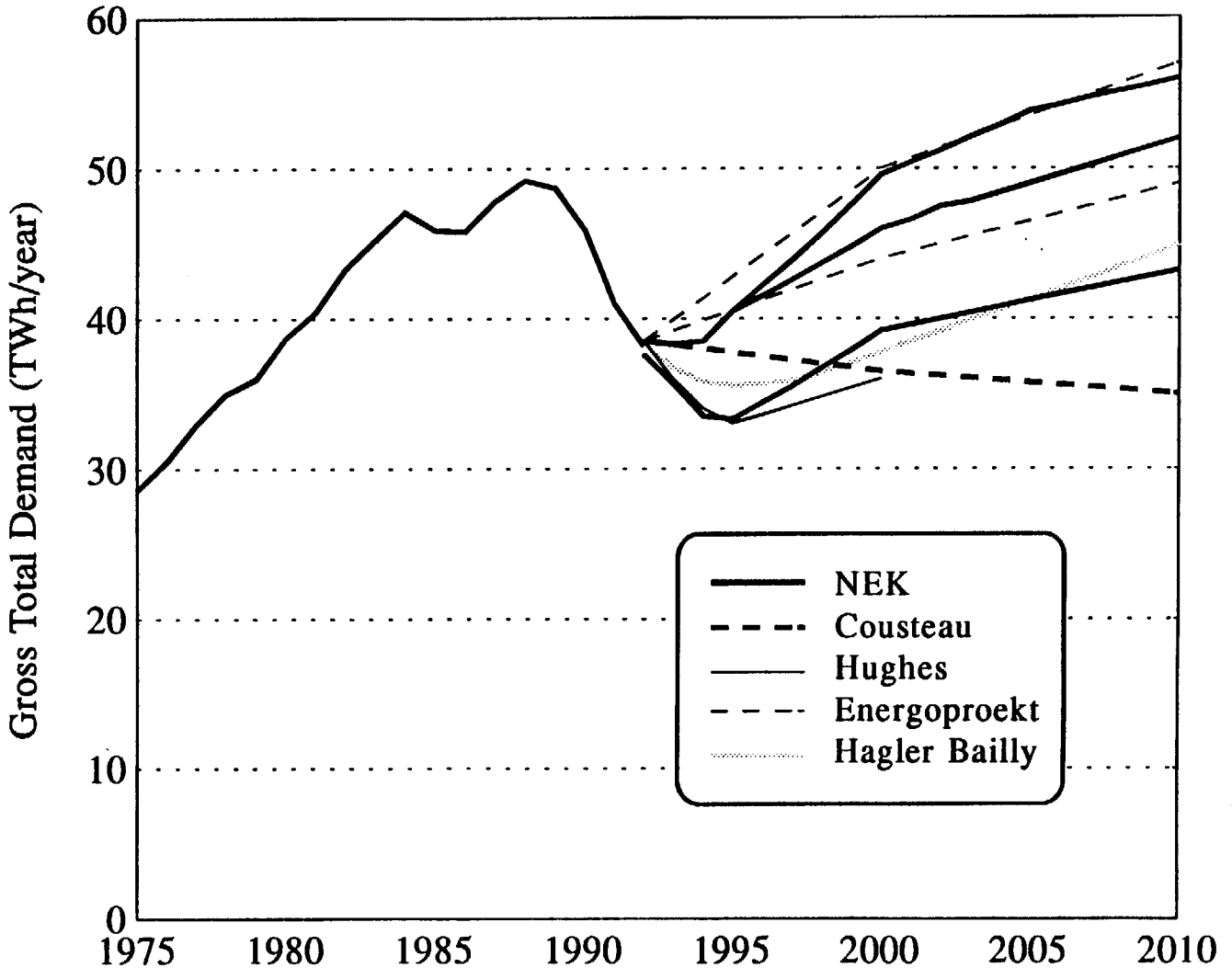
These forecasts establish a range of expected demand in the year 2000 from 35-50 TWh[1]. The spread of these forecasts indicates a high level of uncertainty.

[1] The NEK most likely scenario shows 46 TWh in year 2000.

Exhibit S-1

# Bulgaria - Total Electricity Demand

Comparison of Previous Forecasts

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## S.4 CREATING A POLICY FRAMEWORK TO PROMOTE EFFICIENT USE OF ELECTRICITY IN BULGARIA (Please refer to Chapter 4 for more details)

### S.4.1 Integrated Resource Planning

Integrated resource planning (IRP) is a concept in which the simultaneous consideration of supply-side and demand-side options is required, in order to minimize the cost of energy services to customers, and society as a whole. In the United States, the Energy Policy Act of 1992 requires IRP by all the states, and IRP techniques have been adopted by several countries in Europe. The legal and regulatory framework for energy and electricity is currently being developed in Bulgaria, and the IRP concept is recommended. In Bulgaria, the IRP process should include several actions, carried out in parallel:

- require that electricity agencies (Committee of Energy, National Electric Company, and others) assume IRP responsibilities, through enactment of appropriate legislation, regulations, and institutional development;
- develop a least-cost investment plan, considering all supply-side and demand-side options available to Bulgaria, not only from NEK itself but also other sources;
- evaluate electricity tariffs in comparison with long-run marginal costs determined by the least-cost investment plan, and restructure tariffs as required;
- carry out demonstrations under Bulgarian conditions of DSM policies, DSM technologies, DSM implementation strategies, and DSM financing options;
- based on successful demonstrations, develop policy to promote demand-side management (DSM), analyze DSM options in comparison to base case investment plan, and from those measures that are cost-effective, develop a DSM program.

Hagler, Bailly provides analysis and recommendations to develop some of these concepts further, particularly those related to DSM policy (Chapter 4) and DSM programs (Chapter 5).

### S.4.2 Preliminary Evaluation of Electric Tariffs

Although a detailed estimate of the marginal cost of electricity service in Bulgaria is beyond the scope of our work, Hagler, Bailly has developed preliminary estimates, in order to begin evaluation of the tariffs.

As a basis for analysis, investments are assumed for rehabilitation of thermal capacity and reduce environmental emissions. The analysis shows that annualized marginal cost of delivering 1 kW of capacity on-peak, varies from $33 to $55 per year, depending on the voltage level. In addition, the marginal cost of delivering 1 kWh of energy on-peak, varies from $0.026 to $0.030, depending on the voltage level.

Exhibit S-2 shows a summary preliminary estimate of the medium-term[2] marginal cost of supply for each tariff class, broken out by 1) capacity costs and 2) energy costs, and 3) added together into a simple energy-based tariff (one part, on kWh only), as NEK uses now. The total energy-based marginal cost varies (depending on the customer class, season of the year, and peak/off-peak) between $0.016 (night, for large high-voltage customer) to $0.069 (winter, household customers).

[2]Approximately through the year 2000.

Exhibit S–2
BULGARIA
ESTIMATE OF MARGINAL COST
BY TARIFF CLASS

1. Marginal costs for capacity ($/kW) including capacity and customer costs

| | WINTER COST, $/kW/MONTH | | | SUMMER COST, $/kW/MONTH | | |
|---|---|---|---|---|---|---|
| | Peak | Day | Night | Peak | Day | Night |
| C&I – HV | $2.79 | $0.23 | $0.09 | $1.40 | $0.09 | $0.05 |
| C&I – MV | 3.33 | 0.28 | 0.11 | 1.66 | 0.11 | 0.06 |
| C&I – LV | 4.63 | 0.39 | 0.15 | 2.32 | 0.15 | 0.08 |
| Households | 8.59 | 0.72 | 0.29 | 4.30 | 0.29 | 0.14 |

2. Marginal costs for energy ($/kWh) including energy only

| | WINTER COST, $/kWh | | | SUMMER COST, $/kWh | | |
|---|---|---|---|---|---|---|
| | Peak | Day | Night | Peak | Day | Night |
| C&I – HV | $0.026 | $0.026 | $0.016 | $0.026 | $0.026 | $0.016 |
| C&I – MV | 0.027 | 0.027 | 0.016 | $0.027 | $0.027 | $0.016 |
| C&I – LV | 0.030 | 0.030 | 0.018 | $0.030 | $0.030 | $0.018 |
| Households | 0.030 | 0.030 | 0.018 | $0.030 | $0.030 | $0.018 |

3. Total marginal costs on per kWh basis including energy, capacity, and cusotmer costs

| | WINTER COST, $/kWh | | | SUMMER COST, $/kWh | | |
|---|---|---|---|---|---|---|
| | Peak | Day | Night | Peak | Day | Night |
| C&I – HV | $0.031 | $0.026 | $0.016 | $0.029 | $0.026 | $0.016 |
| C&I – MV | 0.034 | 0.027 | 0.017 | 0.031 | 0.027 | 0.017 |
| C&I – LV | 0.042 | 0.031 | 0.019 | 0.036 | 0.030 | 0.018 |
| Households | 0.069 | 0.033 | 0.019 | 0.049 | 0.031 | 0.019 |

EXHS–4–1.WK1

As far as promoting energy efficiency, the current NEK tariffs include several positive features:

- tariffs for C&I customers based service voltage, rather than other considerations (such as whether the customer is industrial, commercial, institutional, or agricultural);
- different tariffs for C&I customers for winter and summer, and time of day;
- separate tariffs for household customers for day and night usage;
- a time-of-day tariff for purchase of power by NEK from other generators.

The current tariff includes several features which we regard as negative:

- large subsidies for household customers;
- no specific charges in the C&I tariff for capacity (kW); all charges are lumped into an energy charge (kWh);
- no incentives are offered for power factor (cos phi) improvement;
- the power purchase tariff also includes no specific payments for capacity (kW), only for energy (kWh).

The preliminary analysis indicates serious deficiencies in the tariff structure. The tariff structure gives pricing signals to customer which will continue to affect their demand for energy services, and hence NEK's operations and investment planning. Hagler, Bailly recommends that the structure be modified to a structure which reflects the long-run marginal cost of service, based on the results of a detailed tariff study.

### S.4.3 Private Power, and Independent Power Generation

As part of Integrated Resource Planning, consideration must be made of all sources of supply. Independent power generation usually relates to supply of electricity to the grid by facilities not under the ownership or direct control of the electric utility (such as NEK). In Bulgaria, such projects would be developed by the private sector, and could be a first step toward privatization of electricity services.

The potential benefit of independent power to Bulgaria is greater economic efficiency, obtained through competition in power generation, access to financing and additional capital, optimal use of energy resources through combined heat and power, and transfer of new technology.

As part of this A.I.D.-funded project, a separate report was prepared by Hagler Bailly on this subject, entitled "Independent Power Generation in Bulgaria: Assessment of Potential, Impediments and Options", August 1993.

### S.4.4 Demand-Side Management (DSM)

Demand-side management (DSM) refers to a wide variety of activities which are carried out to improve the efficiency of electricity usage by customers, with cooperation from the electric utility company. DSM thus represents a partnership between the electric company and its customer. There can be other partners in DSM programs, such as private sector energy services companies, financial institutions, and energy engineering firms.

DSM includes programs to encourage conservation, energy efficiency, and load management actions. DSM can also include actions to increase power sales in the off-peak periods. DSM is chosen over a supply-side option when DSM is clearly shown to offer a lower cost alternative to the economy of Bulgaria.

However, whereas the calculation may show DSM to be the least cost option for the country as a whole, the calculation may be different when investigated from the utility's perspective. Thus, in some countries, electric utilities have been reluctant to implement DSM, because financial issues have not been adequately resolved. Implementing DSM has not been in the utilities' interest in those countries where the local regulatory process ties revenues only to energy (kWh) sales. In these cases, savings in energy from demand-side programs reduce the sales of the utility (revenues are lost). In some countries, management (and other employee) compensation or bonuses may even be tied to revenue or kWh sales.

For DSM to succeed, it is necessary that the Bulgarian electric utilities be given the proper financial incentive, so that their decisions are able to mirror what is best for the country. The recommended first incentives are:

- allow DSM capital investments by the utility to earn a rate of return which is high enough to encourage the utility to make the investment;
- allow other (non-capital) DSM expenses incurred by the utility to be recovered through tariffs in the same year they are incurred;
- provide utility employee incentives based on services and efficiency, rather than energy sales.

## S.5 DEVELOPMENT OF AN ILLUSTRATIVE DEMAND-SIDE MANAGEMENT PROGRAM FOR BULGARIA (Please refer to Chapter 5 for more details)

### S.5.1 Selection of DSM Measures

The NEK load shape and Bulgarian conditions were used to develop a set of criteria for DSM program design in Bulgaria:

- End-use - addressing the industrial and buildings sectors
- Load shape - addressing the need for peak demand reduction in winter
- Relative costs - recognizing the need to favor low-cost measures
- Equipment and services availability in Bulgaria - recognizing the current economic crisis and the transition to private enterprise and a market economy

Using the limited data available, a DSM measure screening and cost-benefit analysis was carried out, and the following measures appear best able to satisfy the criteria for Bulgaria:

- Low-cost improvements in homes heated with electricity, such as window coverings, weatherstripping, and thermostats
- Low-cost improvements in homes where hot water is heated with electricity, such as improved insulation, flow restrictors, and thermostats
- Retrofit of some incandescent lighting with fluorescent in homes,
- High-efficiency refrigerators,
- Direct load control in the residential and industrial sectors,
- Industrial management, technical, production and energy audits,
- Industrial operations and maintenance improvements,
- Interruptible service and expanded self-generation in industry,
- Computer-based energy management (load monitoring and control) systems in industry.

Other DSM technologies are also likely to find application in Bulgaria, including investments in high efficiency lighting, high efficiency electric motors, and variable speed drive systems.

### S.5.2 Potential of DSM Measures

These measures were evaluated for their potential peak demand reduction and energy savings. Three levels of potential DSM impacts were considered in this step: Technical/Economic Potential, Market Potential, and DSM Program Potential. The three levels are described in Exhibit S-3.

Technical/Economic Potential assesses the energy savings and coincident peak demand savings possible if the commercially available, technically applicable, and economically feasible DSM measures were fully implemented. The analysis was carried out at the sector level (industry or buildings). Based on the data sources available to us (as listed previously), we estimated that the technical/economic potential for electric energy efficiency measures in Bulgaria amounts to:

Peak demand reduction of more than 2,800 MW (48% of current maximum)

Energy savings of more than 7 TWh (29% of current consumption)

A "supply curve" is useful to illustrate the quantity of a good available at various prices. An energy efficiency supply curve plots the various technical measures in rank order on the basis of their cost of conserved energy (CCE, $/kWh). The CCE for each measure is plotted vs. the technical/economic potential of the measure (GWh/year). The supply curve of technical/economic potential for measures in the buildings sector is shown in Exhibit S-4. The curve only shows technologies which have a CCE less than the estimated marginal cost of energy supply (about $0.03/kWh). Exhibit S-5 illustrates the supply curve for the industrial sector. The curve includes two load management technologies that limit peak demand (MW) and are expected to be cost-effective. Because these measures are designed to reduce peak demand, rather than save energy, their CCE is higher than the cost of energy supply.

**Exhibit S-3**
**Evaluating DSM Potential**

Technical/Economic Potential

Which DSM measures are both technically applicable and economically feasible?

What savings (kW and kWh) are possible from these DSM measures?

Market Potential

What proportion of cost-effective DSM measures will be ultimately accepted by consumers on their own (without help from the utility)?

How long will it take for them to accept them?

What savings (kW and kWh) will result?

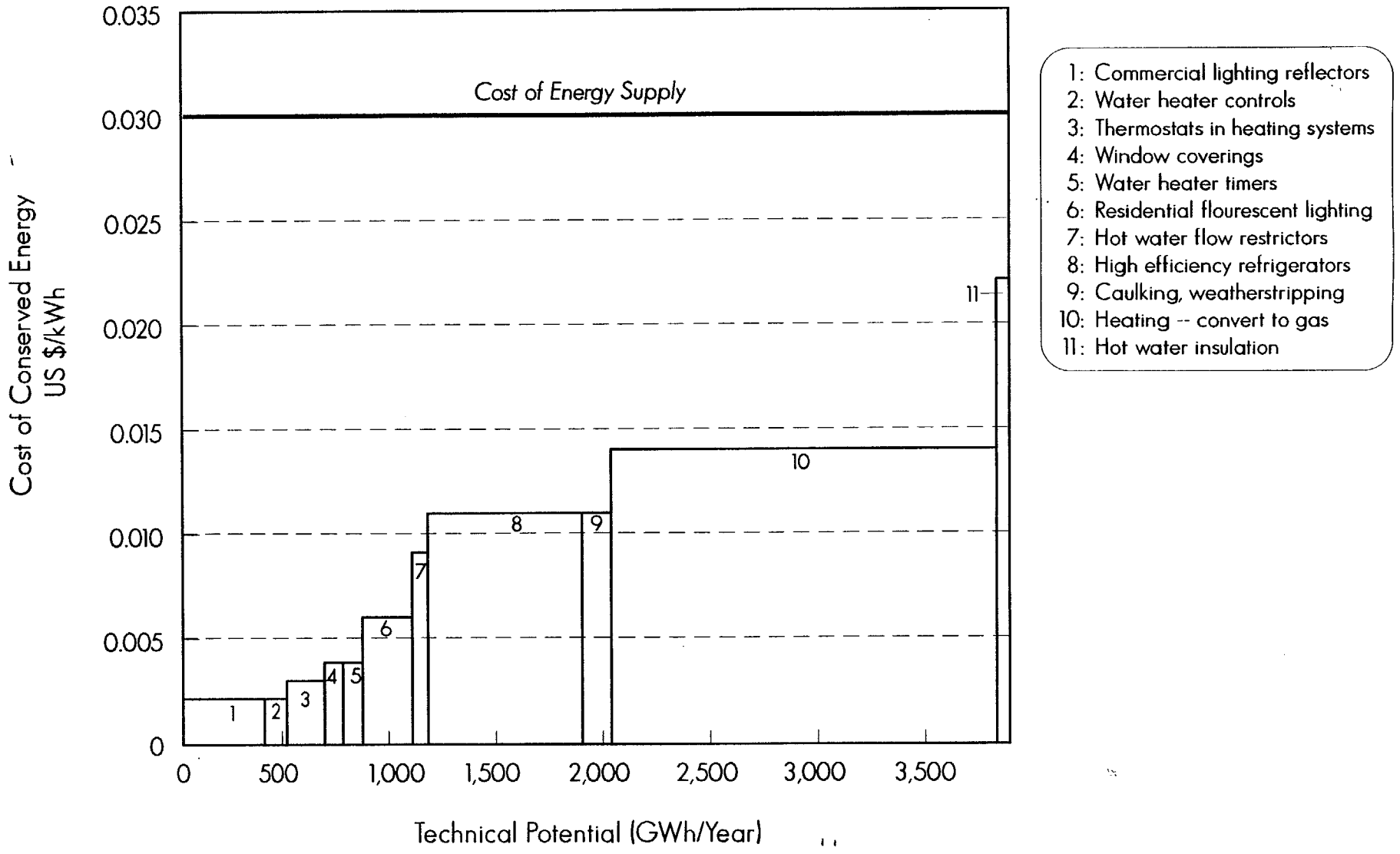
Illustrative DSM Program Potential

What proportion of cost-effective DSM measures will be ultimately accepted by consumers, if the utility provides appropriate incentives through a DSM program?

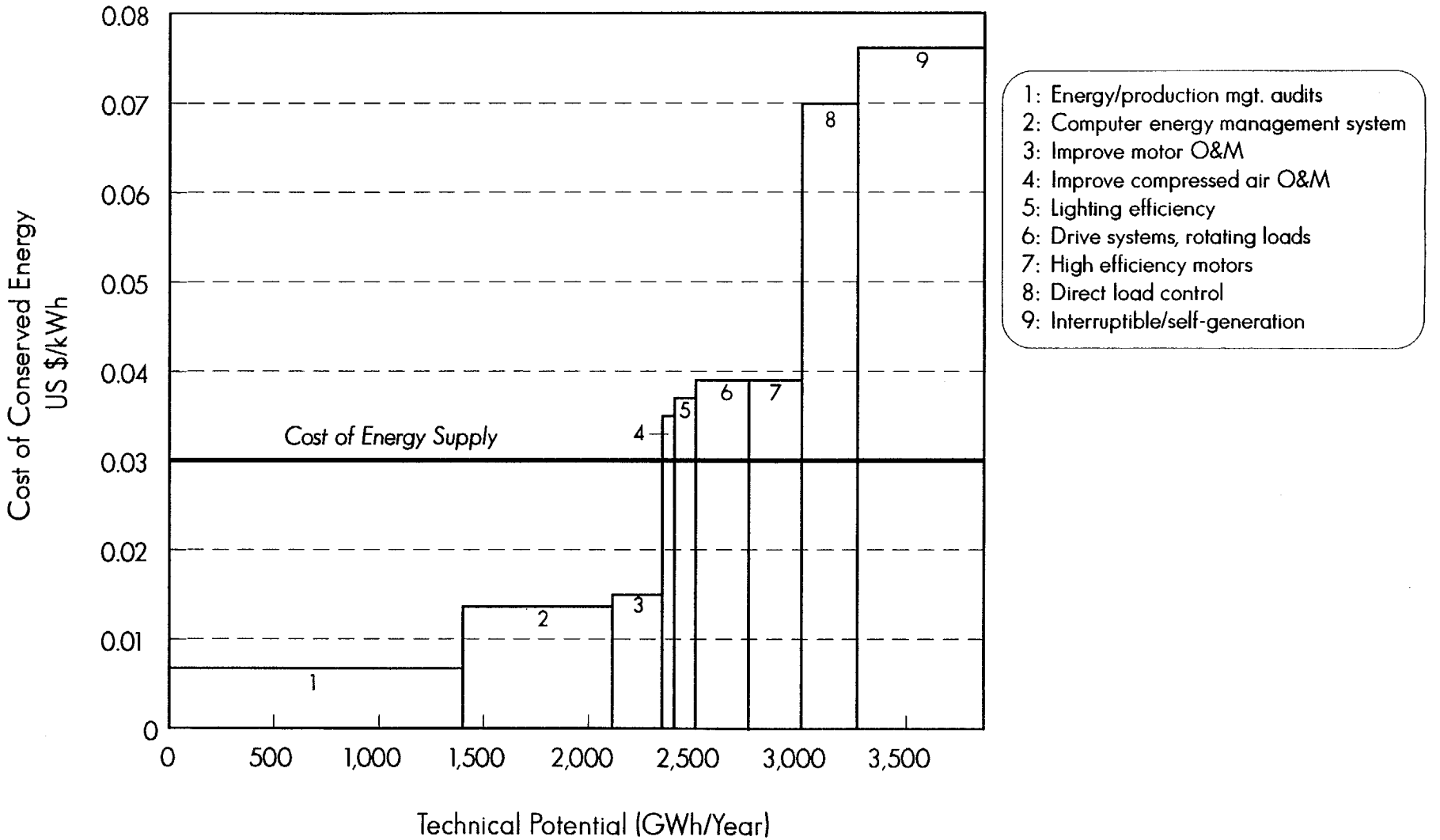
How long will it take for them to accept them?

What savings (kW and kWh) will result?

# Exhibit S-4
## Bulgaria
## Supply Curve -- Technical/Economic Potential (Buildings Sector)



# Exhibit S-5
## Bulgaria
## Supply Curve -- Technical/Economic Potential (Industry Sector)



Market potential assesses the likelihood that the technical potential will in fact be realized, based on normal market forces alone, such as electricity prices and consumer behavior. Some of these market forces influencing market potential in Bulgaria are listed in Exhibit S-6.

Market potential depends on decision maker preferences. A DSM measure that is technically feasible and physically applicable may not be considered cost-effective by different individual home, building, or factory decision makers. Usually decision makers in the same market segment, evaluating the same DSM measure at a given levelized cost may or may not consider it cost-effective to install because of different investment preferences and acceptance criteria.

Market potential indicates the fraction of cost-effective DSM measures that will actually be undertaken by consumers, without a utility-sponsored DSM program. There are many reasons why even cost-effective DSM measures are not implemented: alternative uses of capital, severe limitations on the availability of capital, disinterest in energy conservation, management focus on other concerns or crises, differing opinions regarding other product attributes, perceptions of technical risk, lack of knowledge of the measure, and numerous other normal market frictions and transaction costs which result in a lower number of DSM measures actually being undertaken than are cost-effective.

The estimates of the market potential are based on assumptions regarding market penetration for each measure. These assumptions show low rates of market penetration achieved over a 10-20 year period, consistent with experience in the U.S. and developing countries. In summary, we estimate that the market potential for DSM measures in Bulgaria amounts to 5-7% of the technical/economic potential:

> Peak demand reduction of 150 MW (about 2% of current maximum load from industrial and buildings sectors)
>
> Energy savings of 590 GWh (2% of current consumption by industrial and buildings sectors)

**Exhibit S-6**
**Factors Influencing Investments**
**In Energy Efficiency In Bulgaria**

**Financial Constraints:** There may be insufficient capital available, or the financial risk for energy efficiency may be perceived as being too high. A survey of the 106 largest Bulgarian electrical customers was carried out in December 1992 by DBC. Lack of financing was identified as the key reason for not undertaking energy efficiency investments by 53% of the firms who responded.

**Equipment Availability:** High efficiency equipment may not be available, or other technological limitations may exist. This was cited as the reason for not undertaking energy efficiency investments by 25% of the firms in the Bulgarian survey.

**Subsidized Energy Prices:** Energy prices may not provide the consumer with a sufficient price signal to justify energy efficiency investments. Low electricity prices was identified as the reason for not investing in energy efficiency by approximately 9% of the firms responding to the survey.

**Lack of Information:** Energy users may not be aware of energy efficiency opportunities or may not know how to get the measure implemented.

**Non-Economic Behavior:** Consumers may not make strictly economic behavior but make choices according to other considerations.

**Ownership:** Renters may pay the utility bill, but are unwilling to make improvements to buildings owned by landlords or the state.

The illustrative DSM Program Potential estimates the results of a utility-based incentive program designed to overcome the market imperfections, and thereby increase customer acceptance of energy efficiency measures. Despite the provision of incentives and subsidies, utility-sponsored DSM programs may only result in an actual implementation of 25-50% of the technical potential.

The survey of Bulgarian industries provides some information on market potential. Without incentives (the current situation), the survey found that 57% of the firms interviewed had not implemented energy efficiency measures, even though three-fourths of the total firms were aware of potential options. The survey found that 76% of those interviewed would be interested in energy efficiency programs, if incentives were offered.

While there are several means of establishing impact and cost-effectiveness, assessing market potential generally requires implementing pilot programs. Pilot programs are the best way to obtain actual customer response to the program offered by the utility.

We estimate that the illustrative DSM program potential for Bulgaria amounts to about 35% of the technical potential:

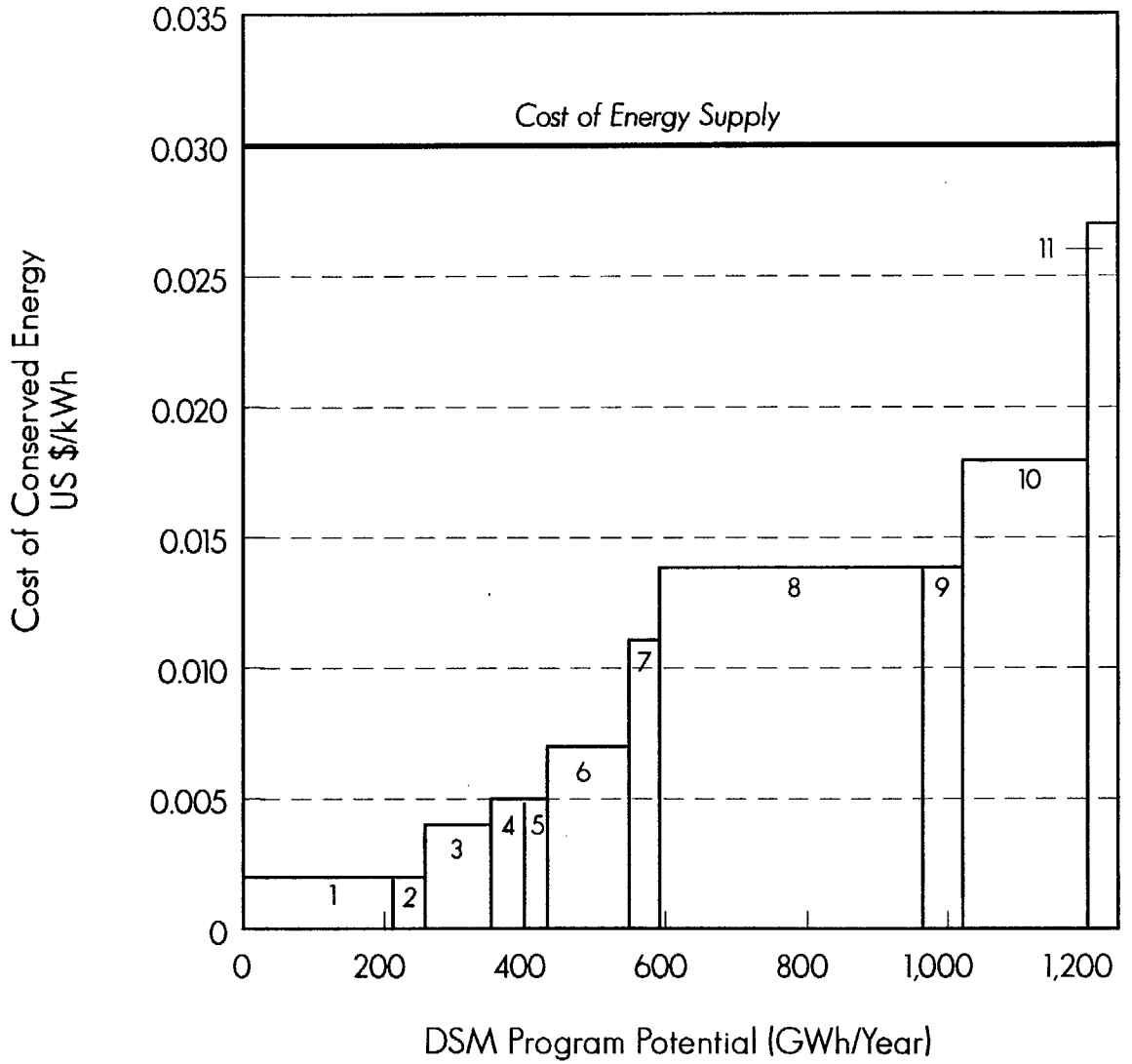
> Peak demand reduction of more than 1,000 MW (16% of current maximum load from industrial and buildings sectors)
>
> Energy savings of 2.8 TWh (10% of current consumption by industrial and buildings sectors)

Thus, the estimated net benefit of the DSM program (subtracting the energy efficiency improvements that would have happened without a program) are:

> Peak demand reduction of more than 900 MW (15% of current maximum load from industrial and buildings sectors)
>
> Energy savings of 2.2 TWh (9% of current consumption by industrial and buildings sectors)

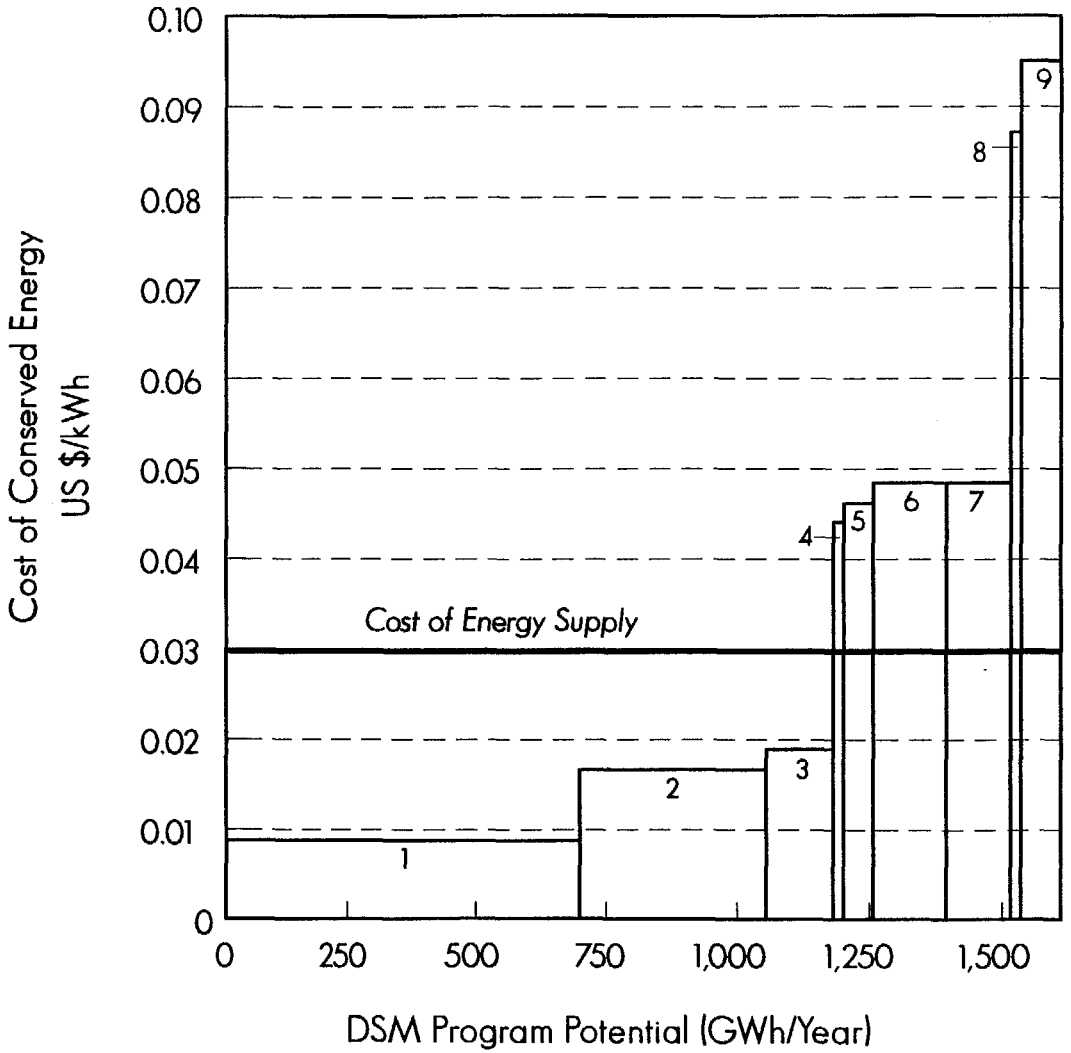
A set of energy efficiency supply curves was generated for the Illustrative DSM program, using DSM Program Potential GWh/year and costs of conserved energy which include the cost of the DSM program development, administration, and evaluation. The supply curve of the Illustrative DSM Program for measures in the buildings sector is shown in Exhibit S-7. The curve only shows technologies which have a CCE less than the estimated marginal cost of energy supply (about $0.03/kWh). Exhibit S-8 illustrates the supply curve for the industrial sector.

# Exhibit S-7
## Bulgaria
## Supply Curve -- Illustrative DSM Program (Buildings Sector)




1: Commercial lighting reflectors
2: Water heater controls
3: Thermostats in heating systems
4: Window coverings
5: Water heater timers
6: Residential flourescent lighting
7: Hot water flow restrictors
8: High efficiency refrigerators
9: Caulking, weatherstripping
10: Heating -- convert to gas
11: Hot water insulation

# Exhibit S-8
## Bulgaria
## Supply Curve -- Illustrative DSM Program (Industry Sector)




1: Energy/production mgt. audits
2: Computer energy management system
3: Improve motor O&M
4: Improve compressed air O&M
5: Lighting efficiency
6: Drive systems, rotating loads
7: High efficiency motors
8: Direct load control
9: Interruptible/self-generation

### S.5.3 Benefit-Cost Analysis of Illustrative DSM Program

The costs of energy efficiency improvements under the Illustrative DSM Program are substantial, peaking at $76 million per year once the program gets fully under way:

| | |
|---|---|
| Year 1: | $4 million |
| Year 2: | $5 million |
| Year 3: | $10 million |
| Year 4: | $19 million |
| Year 5: | $38 million |
| Years 6 - 9: | $76 million per year |

An economic analysis was carried out to determine if these costs could be justified. Based on the annual net benefits (benefits minus costs), and using a discount rate of 10% over an investment planning horizon of 20 years, the following economic evaluation results:

Net Present Value (NPV):

| | |
|---|---|
| DSM in buildings | $129 million |
| DSM in industry | $183 million |
| Total Illus. DSM Program | $312 million |

Benefit/Cost Ratio (total resource cost, TRC):

| | |
|---|---|
| DSM in buildings | 3.35 |
| DSM in industry | 2.28 |
| Total Illus. DSM Program | 2.58 |

Internal rate of return (IRR):

| | |
|---|---|
| DSM in buildings | 92% |
| DSM in industry | 38% |
| Total Illus. DSM Program | 48% |

Another evaluation is the cost of conserved energy (CCE). In this calculation, the NPV of the annual cost stream is divided by the NPV of the annual energy savings stream to obtain an estimate in $/kWh. This calculation is somewhat distorted, since it puts all costs against energy, giving no recognition to peak demand reduction. However, it does give a direct basis for comparison against the marginal cost of energy supply, which we calculated as about $0.03/kWh. The CCE for the Illustrative DSM Program is calculated as:

| | |
|---|---|
| DSM in buildings | $0.013/kWh |
| DSM in industry | $0.024/kWh |
| Total Illus. DSM Program | $0.020/kWh |

The values of IRR are well above the common values of minimum acceptable rate of return (hurdle rates) used in project evaluation by the World Bank, EBRD, or other lenders. The cost of the energy conserved is only a little more than half the marginal cost of energy supply. The other economic evaluation criteria all show very positive results, and thus we conclude that the Illustrative DSM program is a very attractive investment for Bulgaria.

### S.5.4 Effect of the Illustrative DSM Program on the Demand Forecast

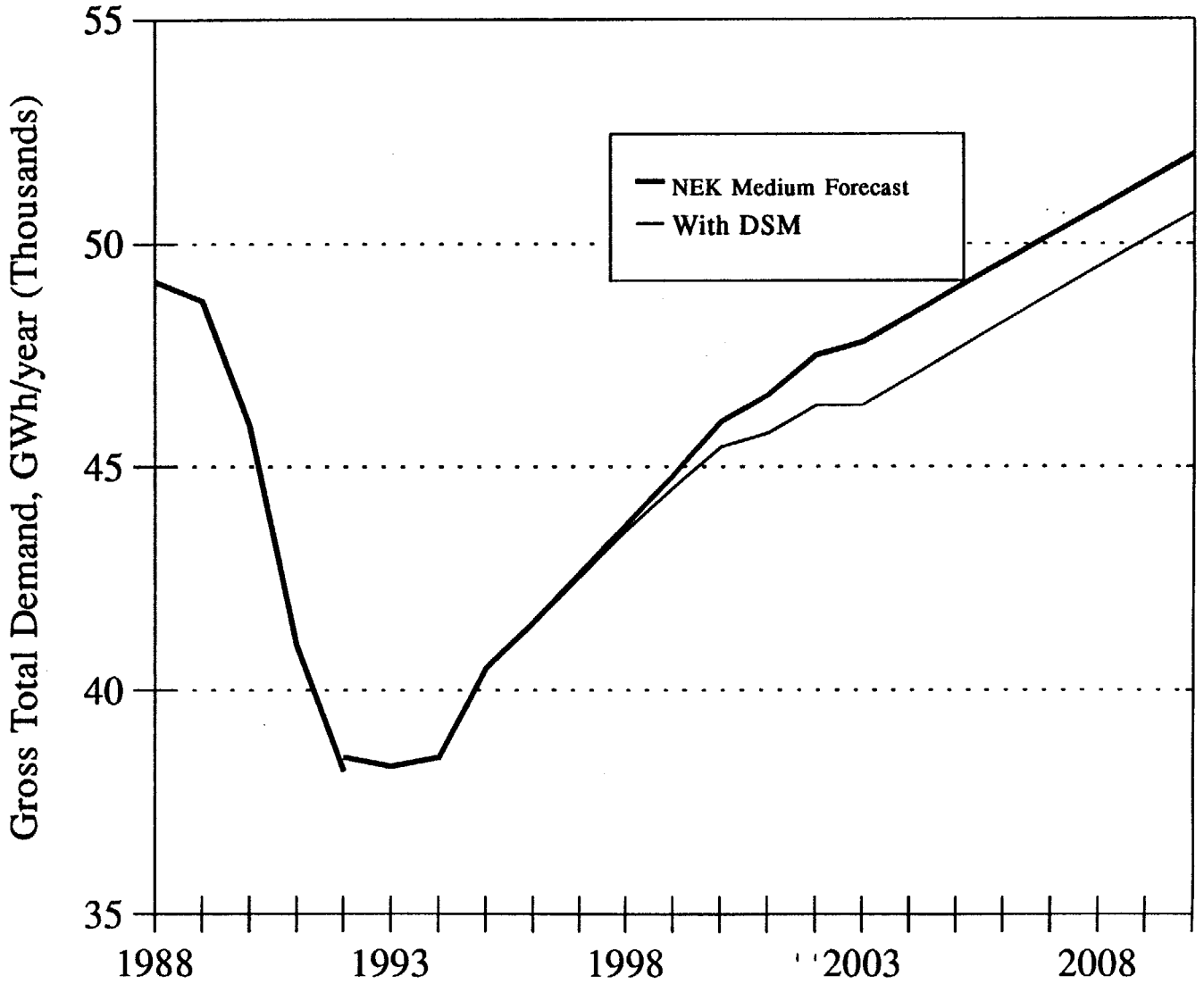
Finally, the net effect of the Illustrative DSM Program was incorporated into the NEK medium-case demand forecast, so that the impact on annual energy requirements can be seen.

Exhibit S-9 illustrates the impact of the Illustrative DSM program on annual energy demand. The effect is to reduce the growth of demand until about year 2004. After that time, energy demand will begin to grow unless more DSM measures can be implemented.

Exhibit S-9

# Bulgaria - Total Electricity Demand

Effect of Illustrative DSM Program



### S.5.5 Action Plan to launch DSM Program in Bulgaria

Implementing DSM appears to be part of a least-cost power sector investment program for Bulgaria. Initiating activities in DSM will require a demonstration project, in order to establish the local context in which DSM technologies, policies, financing mechanisms can succeed.

The Illustrative DSM Program described in this report is based on preliminary data, which is very limited. This limited data is insufficient to fully evaluate the very large investments required.

However, the preliminary analysis in this report serves as a basis for identifying the next steps to implementing the program. These activities should be pursued in parallel to achieve early success. The key actions for the next 1-2 years are summarized below.

- **Develop and Implement Pilot DSM Programs:** To gain more experience and collect data in Bulgaria, pilot DSM programs for the buildings and industrial sectors should be designed and implemented at one or more distribution branches of NEK. One of the key tasks is the development of the level of incentives or other expenditures to be made by NEK for the program, and the method by which NEK will recovery revenues lost by the energy savings. Developing pilot DSM programs also involves a number of tasks to resolve issues such as market research, program design, selection of technical measures, screening of applications, financing options, implementation by private sector firms, collection of payments by NEK, independent evaluation, and program redesign.

- **Institutional Development:** A parallel step is needed to develop laws and regulations necessary to implement utility Integrated Resource Planning. Within the IRP framework, regulations next need to be put in place to ensure that development of the DSM potential proceeds at the optimum rate. Further, COE and NEK should establish departments responsible for IRP, DSM, and customer service.

- **Load Research and DSM Assessment:** The customer service department at NEK would be assigned to carry out load research, to collect data on energy usage by customers. This project will measure the dynamics of specific loads and then combine these data with statistical and building simulation models to evaluate DSM potential. These additional data should be used to perform a detailed DSM cost-benefit assessment.

# 1. INTRODUCTION

## 1.1 PROJECT OVERVIEW

This report presents partial results of work performed as part of the energy sector assistance provided to Bulgaria by the U.S. Agency for International Development. It was prepared as part of Task 1 - Electricity Sector Study and Action Plan, in coordination with the European Community, by RCG/Hagler, Bailly, Inc. The report investigates opportunities to improve management of demand, through a demand-side management (DSM) program.

### 1.1.1 Background and Perspective

The Natsionalna Elektricheska Kompania (NEK, or the National Electric Company of Bulgaria), is a joint stock company now wholly owned by the state. The Committee of Energy (COE) serves as the government organization responsible for oversight of NEK and national planning in the power sector.

An integrated electric utility company, NEK is responsible for the production, transmission and distribution of electricity and the production and sale of heat. The company was established by Decree No. 46 of November 7, 1991 of the Council of Ministers of Bulgaria. NEK's assets amount to approximately 100 billion leva (U.S. $4 billion). NEK operates through a network of 28 electricity supply branches and ten generation branches. Its total staffing is approximately 30,000.

In 1991 total installed capacity in Bulgaria was 12,074 MW, of which 10,460 MW is owned by NEK. District heating companies have an installed capacity of 574 MW in combined heat and power . Industrial enterprises have an installed capacity of 1,040 MW, mostly also combined heat and power.

### 1.1.2 Objective and Scope

The objective of this study area was to develop recommendations for improving load management.

The scope of the analysis was limited to analysis of the following data:

- reports and other published data provided by NEK and COE;

- electronic spreadsheets of monthly energy consumption for 1991-92 for 106 largest consumers, provided by NEK;
- survey of largest consumers, carried out by Hagler, Bailly and DBC on behalf of COE;
- energy audits carried out by International Resources Group in Bulgaria under the USAID Emergency Energy Program.

The scope of work is described below:

a. Document current and historical use of electricity in Bulgaria, using data obtained from COE and NEK.

b. Review demand forecasts prepared by NEK and others.

c. Carry out a survey of the largest electric energy users to determine their use of electricity and plans for the future.

d. Review the results of energy audits conducted in Bulgaria and other countries in the region to determine potential demand management.

e. Carry out a survey of the largest electric energy users to determine their use of electricity and attitudes toward energy conservation.

f. Develop an illustrative demand-side management investment program.

g. Estimate the potential for electrical energy conservation in industry and buildings.

h. Estimate the potential for peak load management and load-shifting.

i. Develop a draft demand-side management investment program.

j. Present the results to NEK and COE.

## 1.2 HISTORICAL ELECTRICITY USE

Beginning in 1990, the Bulgarian economy went into severe recession. Export markets, which had been focused on the Soviet Union, disappeared as the economies of the former Soviet Republics weakened substantially. Bulgaria was unable to reorient its markets to the West and to other countries in Central Europe, previously under the domination of the Soviets, because of political and institutional barriers and the inferior quality of the products available for export.

The lack of markets and the inability to sell products initially raised inventory levels, but eventually resulted in reduced plant operations and, in many cases, the shutdown of the plants, either temporarily or permanently. Some industries were hit harder than others.

Exhibit 1-1 illustrates the historical electrical energy balance in Bulgaria for 1975 and 1980-92.

Key points shown in Exhibit 1-1 include the following:

- Total consumers' electric energy demand in Bulgaria has taken a sharp drop, and is now 25% less than the maximum recorded in 1988. After dropping about 6% in 1990, total energy demand plummeted more than 13% during 1991 and dropped a further 7% during 1992.

- However, the reduction in electricity usage was not uniform across all sectors. Until 1992, the drop in demand was concentrated, for the most part, in the industrial sector as this sector fought to adjust to a market economy.

- Transmission and distribution losses increased substantially in 1991. This is probably due to energy diversion following increases in tariffs.

- Peak power demand (absolute maximum recorded during the year) has reduced, but much less than energy demand, and is now 15% less than the maximum recorded in 1989. The drop in 1990 (from 8,332 MW to 8,111 MW) amounted to 2.6% and in 1991 a further 7.7% to 7,489 MW and finally to 7,050 MW in 1992.

- Classifying energy sales (GWH/year) into three groups, reductions since 1988 are as follows:

  -- industrial sales are down 34%

  -- household sales are down 4%

  -- other (agriculture, transportation, public buildings) sales are down 28%

- Power generation by industrial enterprises peaked in 1985 at 4,688 GWh, and has since declined by 33%.

Exhibit 1-2 presents the peak demand for each month of 1991. The maximum was recorded in January (7,500 MW), and August experienced the lowest peak (4,300 MW). The difference of more than 3,000 MW is attributed to the demand for heating.

## Exhibit 1–1

## BULGARIA
## HISTORICAL ELECTRICITY BALANCE

| | GWh/year | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1975 | 1980 | 1981 | 1982 | 1983 | 1984 | 1985 | 1986 | 1987 | 1988 | 1989 | 1990 | 1991 | 1992 |
| **Gross Generation** | **24,965** | **34,841** | **37,045** | **40,634** | **42,863** | **44,672** | **41,633** | **41,821** | **43,474** | **45,007** | **44,327** | **42,121** | **38,891** | **36,437** |
| Power Plant Auxiliaries | 2,668 | 3,640 | 3,897 | 4,315 | 4,577 | 4,661 | 4,544 | 4,595 | 4,766 | 4,897 | 4,841 | 4,623 | 4,221 | 3,986 |
| Auxiliaries (pct of net production) | 10.7% | 10.4% | 10.5% | 10.6% | 10.7% | 10.4% | 10.9% | 11.0% | 11.0% | 10.9% | 10.9% | 11.0% | 10.9% | 10.9% |
| **Net Generation** | **22,296** | **31,201** | **33,148** | **36,319** | **38,286** | **40,011** | **37,089** | **37,226** | **38,708** | **40,110** | **39,486** | **37,498** | **34,670** | **32,451** |
| Imports | 3,902 | 4,698 | 4,497 | 4,441 | 4,582 | 4,636 | 5,959 | 4,571 | 4,673 | 4,450 | 4,937 | 5,387 | 3,082 | 2,700 |
| Exports | 279 | 866 | 1,095 | 1,794 | 2,221 | 2,243 | 1,655 | 599 | 324 | 304 | 548 | 1,597 | 959 | 1,000 |
| Power Purchases from Factories & Others | | | | | | | | | | 773 | 774 | 735 | 754 | 750 |
| **Total For Distribution** | **25,920** | **35,033** | **36,551** | **38,966** | **40,647** | **42,403** | **41,393** | **41,198** | **43,056** | **44,256** | **43,875** | **41,288** | **36,793** | **34,151** |
| Distribution Losses | 2,387 | 3,454 | 3,695 | 3,888 | 4,046 | 4,301 | 4,016 | 4,170 | 4,413 | 4,762 | 4,656 | 4,443 | 5,191 | 4,576 |
| Losses (pct of for distribution) | 9.2% | 9.9% | 10.1% | 10.0% | 10.0% | 10.1% | 9.7% | 10.1% | 10.2% | 10.8% | 10.6% | 10.8% | 14.1% | 13.4% |
| **Final Sales** | **23,533** | **31,579** | **32,856** | **35,077** | **36,601** | **38,102** | **37,376** | **37,027** | **38,643** | **39,494** | **39,219** | **36,845** | **31,602** | **29,575** |
| Household Sector | 4,588 | 6,844 | 6,992 | 8,105 | 8,516 | 9,444 | 9,552 | 8,685 | 9,445 | 9,935 | 10,183 | 10,475 | 10,404 | 9,541 |
| Industry Sector | 14,306 | 17,524 | 18,498 | 19,227 | 20,004 | 20,414 | 20,038 | 20,283 | 20,674 | 21,208 | 20,815 | 19,386 | 15,013 | 14,013 |
| Other Sectors | 4,640 | 7,211 | 7,366 | 7,746 | 8,081 | 8,244 | 7,786 | 8,059 | 8,524 | 8,351 | 8,221 | 6,984 | 6,185 | 6,021 |
| Factory Self–Generation | 3,000 | 4,500 | 4,500 | 4,500 | 4,500 | 4,553 | 4,688 | 4,378 | 4,435 | 4,339 | 4,281 | 3,751 | 3,547 | 3,150 |
| **Total Consumers' Demand** | **26,533** | **36,079** | **37,356** | **39,577** | **41,101** | **42,655** | **42,064** | **41,405** | **43,078** | **43,833** | **43,500** | **40,596** | **35,149** | **32,725** |
| **Gross Peak Demand (MW)** | | **6,922** | | | | | **7,878** | **7,514** | **7,853** | **8,114** | **8,332** | **8,111** | **7,489** | **7,500** |
| Load factor | | | | | | | | | | | | | | |
| based on Total for Distribution | | 0.58 | | | | | 0.60 | 0.63 | 0.63 | 0.62 | 0.60 | 0.58 | 0.56 | 0.52 |
| based on Net Generation | | 0.51 | | | | | 0.54 | 0.57 | 0.56 | 0.56 | 0.54 | 0.53 | 0.53 | 0.49 |
| based on Gross Generation | | 0.57 | | | | | 0.60 | 0.64 | 0.63 | 0.63 | 0.61 | 0.59 | 0.59 | 0.55 |

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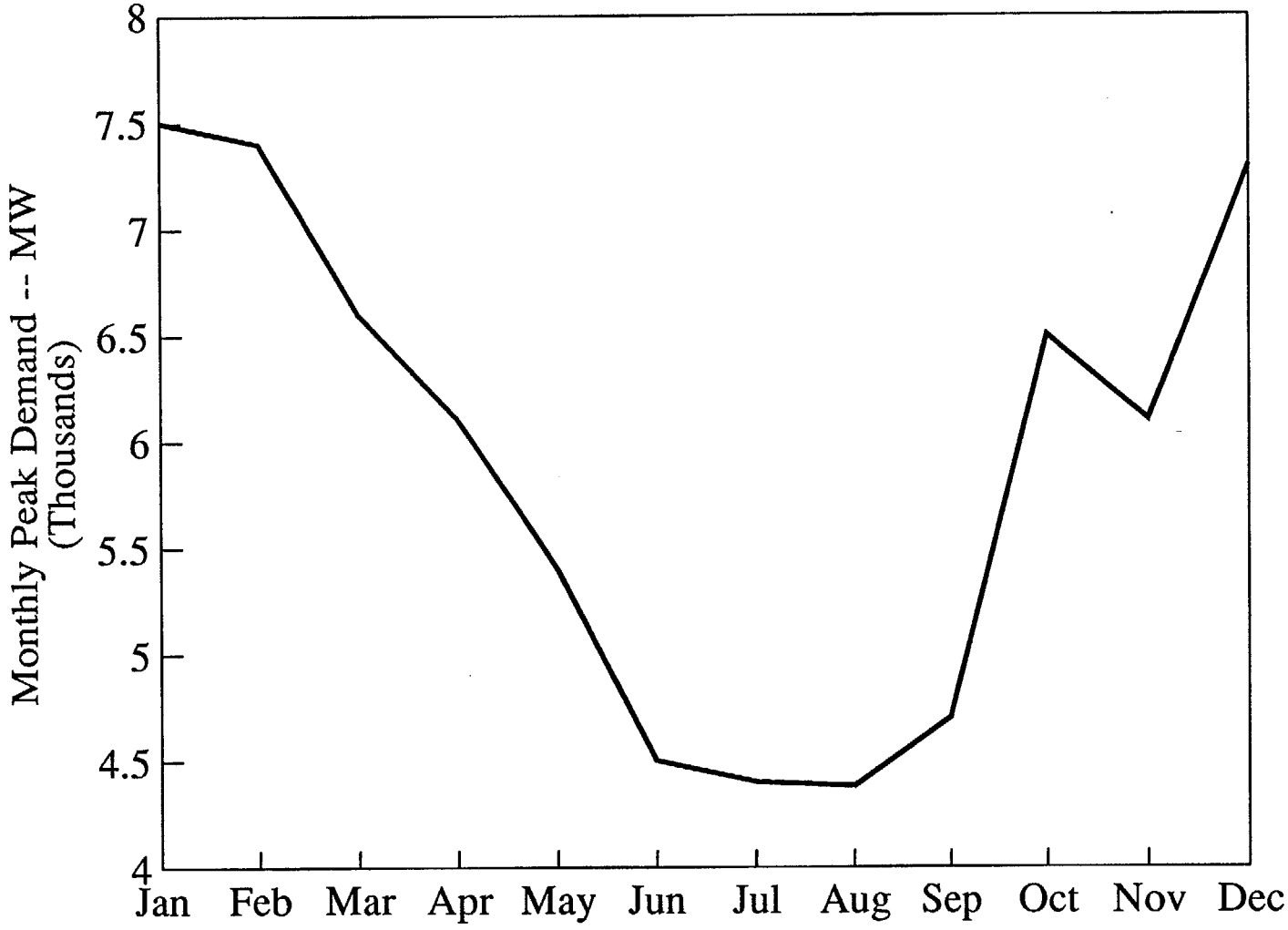
Exhibit 1-2

# Peak Demand by Month
# Bulgaria 1991




1991

Exhibit 1-3 presents the load duration curve for the NEK system for two years, 1982 and 1991. The difference between the two curves shows that most of the reduction in demand has occurred during summer months, and that some reduction has occurred during off-peak periods in the winter.

Exhibit 1-4 shows the daily load curve for typical working days in January 1991 and July 1991. The load swing in winter is only about 13% between peak and minimum, whereas in summer it is more than 25%.

### 1.2.1 Industrial and Commercial Sales by NEK

Industrial electric energy sales remained fairly constant during the latter part of the 1980s at 20-21,000 GWh per year through 1989. In 1990, sales decreased about 7% and in 1991, sales decreased a further 23%.

Data were provided by NEK for the breakdown of electricity consumption by industrial sector, and individually for the 106 largest electricity consumers. These data are summarized in Exhibit 1-5.

The dramatic drop in industrial electricity use in 1991 from 1990 was virtually universal across all sectors. Plants reduced their operations significantly and some shut down completely. The data indicate the greatest declines (using 1989 as a base) in the following sectors:

- chemicals (38%)
- pulp & paper (45%)
- timber (34%)
- food & beverage (25%)
- construction (30%)
- public sector buildings (34%)

### 1.2.2 Household Sales by NEK

During the decade of the 1980s, the price of electricity to households remained constant, and so, with inflation, the real price of electricity drifted downwards. No real increases in household tariffs occurred until 1992.

Referring back to Exhibit 1-1, household electricity demand increased steadily over the several years leading up to 1991. During 1991, while total electricity consumption was decreasing almost 15%, household consumption decreased by less than 1%. However, with substantial increases in tariffs, reductions in demand began in 1992, and sales were down about 8%.

Exhibit 1-3

**Load Duration Curve**
**Bulgaria -- 1991 and 1982**

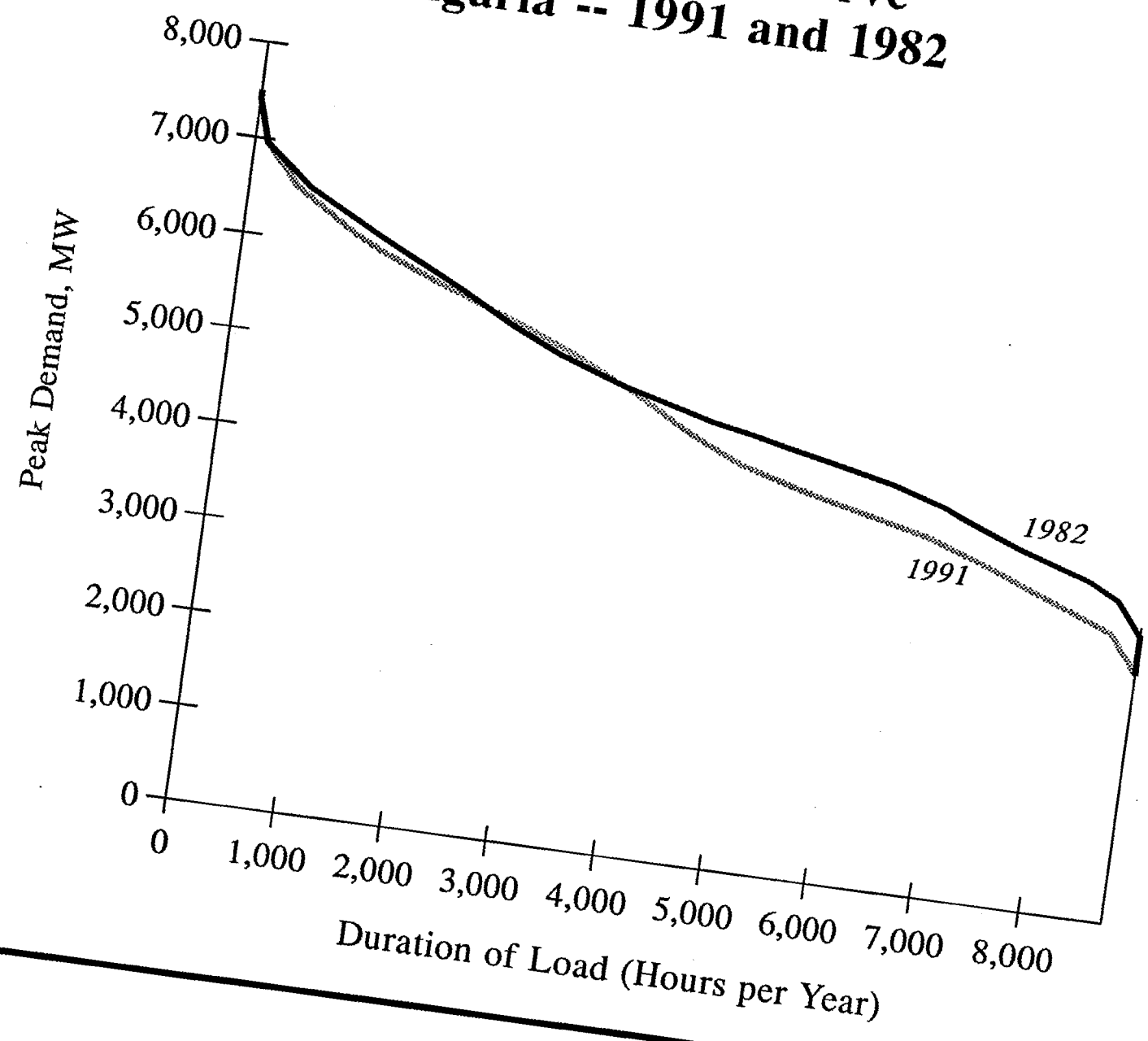


Exhibit 1-4

# Daily Load Profile - Bulgaria

## Average Day in January & July

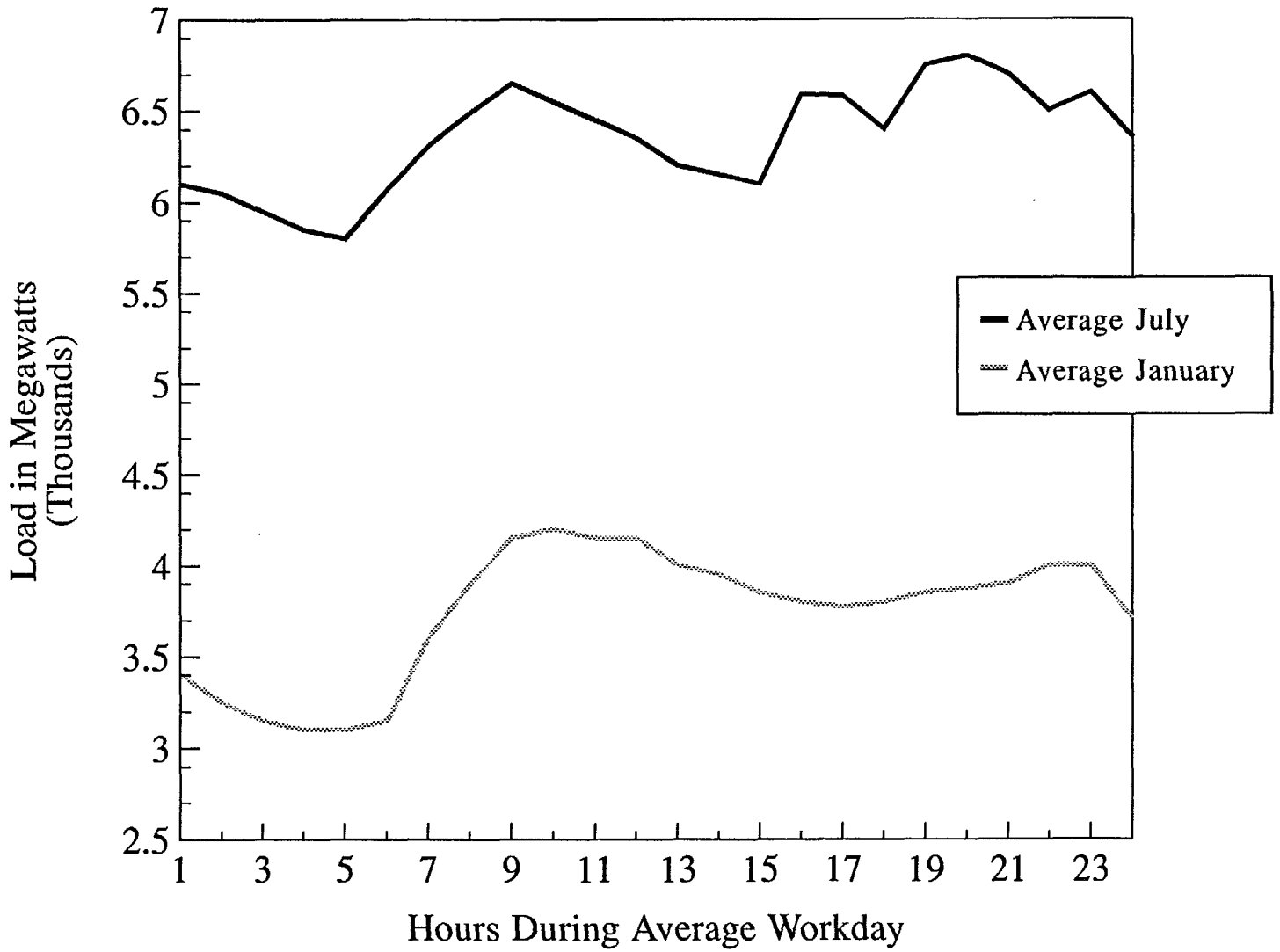


**Exhibit 1–5**
**BULGARIA**
**RECENT ELECTRICITY SALES**
**TO INDUSTRY SECTORS AND LARGEST CUSTOMERS**

| | 1987 | 1988 | 1989 | 1990 | 1991 | 1992 |
|---|---|---|---|---|---|---|
| Ferrous Metals | 2,988 | 3,029 | 2,980 | 2,869 | 2,640 | 2,481 |
| Promet (S) | | | | | 37 | 44 |
| Kremikovtsi (S) | | | | | 849 | 764 |
| Stomana | | | | | 446 | 487 |
| Other | | | | | 1,308 | 806 |
| **Non–ferrous Metals** | **1,878** | **1,906** | **1,863** | **1,777** | **1,635** | **1,537** |
| Medril Mihi | | | | | 44 | 54 |
| Chiprovech | | | | | 15 | 22 |
| Polimet | | | | | 41 | 40 |
| MDP "Elatsite" | | | | | 0 | 17 |
| GORYBSO–AD IVru | | | | | 27 | 26 |
| OTSK–OOD | | | | | 118 | 117 |
| Olovo i Tsink | | | | | 24 | 22 |
| OP "Elatsite" | | | | | 161 | 400 |
| Redki Metali | | | | | 34 | 18 |
| Medodobiven K. (S) | | | | | 152 | 260 |
| D. Blagoev (S) | | | | | 198 | 200 |
| Alumina | | | | | 35 | 34 |
| OTSM (S) | | | | | 41 | 40 |
| Other | | | | | 746 | 286 |
| **Chemicals** | **6,350** | **6,378** | **4,443** | **3,771** | **3,017** | **2,752** |
| Kaltsit (S) | | | | | 50 | 55 |
| Neftohim (S) | | | | | 195 | 116 |
| Agropolihim | | | | | 143 | 123 |
| Polimeri | | | | | 347 | 114 |
| TK "Sodi"–star | | | | | 192 | 38 |
| F "Neohim" | | | | | 207 | 175 |
| Agrabiohim | | | | | 576 | 581 |
| HIMKO | | | | | 452 | 455 |
| Yambolen | | | | | 50 | 54 |
| Plasthin | | | | | 17 | 21 |
| Lateks (S) | | | | | 10 | 7 |
| Geoson | | | | | 25 | 23 |
| Gavril Genov (S) | | | | | 14 | 13 |
| P. Karaminchev | | | | | 12 | 13 |
| Smyadovo–OOD | | | | | 11 | 5 |
| Odesos (S) | | | | | 10 | 13 |
| Antibiotik (S) | | | | | 107 | 109 |
| Other | | | | | 601 | 837 |
| **Engineering – metallic products** | | | **2,212** | **2,159** | **1,987** | **1,867** |
| Energorem. 3–D (S) | | | | | 25 | 19 |
| K–t za Traktori | | | | | 18 | 12 |
| Osam | | | | | 26 | 10 |



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**Exhibit 1–5**
**BULGARIA**
**RECENT ELECTRICITY SALES**
**TO INDUSTRY SECTORS AND LARGEST CUSTOMERS**

| | 1987 | 1988 | 1989 | 1990 | 1991 | 1992 |
|---|---|---|---|---|---|---|
| Akumikar | | | | | 13 | 17 |
| Fitingi | | | | | 30 | 24 |
| LEKO–KO | | | | | 102 | 34 |
| SLZ (S) | | | | | 149 | 21 |
| ZTM–OOD (S) | | | | | 25 | 16 |
| Korabostr. –OOD | | | | | 10 | 11 |
| Madara | | | | | 45 | 21 |
| G. Dimitrov (S) | | | | | 16 | 14 |
| TKEP "6 Sept." (S) | | | | | 18 | 11 |
| ZMM–AD (S) | | | | | 14 | 15 |
| MK "VMZ" | | | | | 88 | 84 |
| Progres | | | | | 17 | 13 |
| Varn. Korabostr. (S) | | | | | 31 | 41 |
| Veslets 91 | | | | | 39 | 52 |
| KAMET (S) | | | | | 99 | 36 |
| Rekora (S) | | | | | 5 | 15 |
| Other | | | | | 1,215 | 1,400 |
| **Electrical & Electronics** | | | **817** | **700** | **686** | **648** |
| B. Kolarov | | | | | 12 | 26 |
| Eltos | | | | | 10 | 11 |
| Feromagniti | | | | | 21 | 20 |
| Svetlkna | | | | | 19 | 15 |
| Elprom–Dinamo | | | | | 14 | 9 |
| Elprom–ZEM–ad (S) | | | | | 0 | 14 |
| D S U | | | | | 29 | 17 |
| Elima | | | | | 22 | 19 |
| Elkom (S) | | | | | 9 | 12 |
| Other | | | | | 551 | 506 |
| **Building Materials** | | **1,395** | **1,305** | **1,161** | **1,068** | **1,004** |
| Beloiz. Tsiment | | | | | 88 | 55 |
| Devn. Tsiment | | | | | 120 | 103 |
| Bulkan | | | | | 33 | 37 |
| Izida | | | | | 16 | 16 |
| Pl. Tsiment | | | | | 50 | 60 |
| Zl. Panega | | | | | 84 | 89 |
| Han Asparuh (S) | | | | | 18 | 16 |
| Kaolin (S) | | | | | 8 | 18 |
| Other | | | | | 652 | 610 |
| Timber | | | 419 | 380 | 304 | 277 |
| **Pulp & paper, wood products** | | | **637** | **481** | **385** | **351** |
| Rulon–Iskar (S) | | | | | 26 | 27 |
| PHHI | | | | | 29 | 24 |
| TKTSH | | | | | 34 | 57 |
| ZMK (S) | | | | | 76 | 32 |



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## Exhibit 1–5
## BULGARIA
## RECENT ELECTRICITY SALES
## TO INDUSTRY SECTORS AND LARGEST CUSTOMERS

| | 1987 | 1988 | 1989 | 1990 | 1991 | 1992 |
|---|---|---|---|---|---|---|
| Lesil | | | | | 49 | 17 |
| St. Kirajiev (S) | | | | | 55 | 55 |
| TKHTS (S) | | | | | 31 | 13 |
| Other | | | | | 85 | 126 |
| **Glass** | | | **424** | **504** | **494** | **466** |
| Belopal | | | | | 42 | 38 |
| Kitka | | | | | 29 | 25 |
| Fayans | | | | | 24 | 26 |
| Rubin | | | | | 35 | 25 |
| Drushba | | | | | 44 | 44 |
| Kvarts | | | | | 22 | 18 |
| Diamant (S) | | | | | 21 | 21 |
| Other | | | | | 276 | 269 |
| **Textiles** | | **784** | **767** | **662** | **609** | **572** |
| Manuela | | | | | 18 | 23 |
| Dobruja | | | | | 8 | 9 |
| Sliteks | | | | | 21 | 21 |
| Vratitsa | | | | | 18 | 14 |
| Other | | | | | 543 | 505 |
| **Food & Beverage** | | **1,454** | **1,521** | **1,312** | **1,207** | **1,135** |
| N. Vaptsarov | | | | | 6 | 33 |
| Tyot. Kombinat (S) | | | | | 12 | 11 |
| MEZ "Kambana" (S) | | | | | 8 | 8 |
| SKPPPMYA (S) | | | | | 14 | 8 |
| Other | | | | | 1,167 | 1,075 |
| **Other Industries** | | | **1,047** | **1,066** | **981** | **922** |
| Bules (S) | | | | | 14 | 11 |
| Cherno More (S) | | | | | 8 | 9 |
| Construction | 1,091 | 1,139 | 994 | 896 | 740 | 696 |
| Agriculture | 1,143 | 1,094 | 1,070 | 995 | 870 | 873 |
| Transport & Communications | 1,441 | 1,489 | 1,493 | 1,483 | 1,400 | 1,392 |
| Public Sector | 4,849 | 4,629 | 4,664 | 3,610 | 3,175 | 3,061 |

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## 1.3 FACTORS INFLUENCING DEMAND

Several factors influence the demand for electricity. The two primary effects are:

- *Income* - For the industrial sector, the health of the economy, both local and worldwide, determines the demand for goods and services, and in turn, this determines the demand for electricity. For households, income affects ability to buy electric appliances or even electric energy itself.

- *Price* - Low electricity tariffs encourage greater consumption, and higher prices should lead to conservation. The structure of tariffs (for example, amount charged to large industrial customers as compared to households) is very important in determining sector demand.

Secondary effects are:

- *Structure of industry* - As the prices of energy and inputs increase, the cost of producing goods increases. Those goods that have the greatest increases in productivity or are the most energy efficient in production will tend to be relatively lower cost industries, and the demand for goods will shift towards these industries. This shift will bring about a scale effect as inefficient plants close and a substitution effect as demand is shifted to the more electricity-efficient industries.

- *Energy conservation programs* - The government can directly affect the demand for electricity through the level of its promulgation of energy conservation programs.

- *Privatization* - The government indirectly affects the use of electricity by its industrial policies. The industries that the government promotes through either subsidies or by assisting in the privatization process should become more healthy, affecting the eventual demand for electricity.

- *Commercial services* - The privatization process will also spur the development of the commercial sector, which will require electricity for lighting, cooking, refrigeration, heating, ventilation and air conditioning.

- *Weather conditions* - Bulgaria's peak demand increases by more than 3,000 MW in the winter, so a cold winter will cause an increase in demand.

- *Household formation* - Population growth and residential construction leads to the formation of new households and the creation of new customers. Since 1980, population growth has average only about 0.2% per year in Bulgaria.

- *Regional differences* - The demand for electricity varies by region, because of the concentration of industry, the size of the population, and differing weather patterns. The historical regional distribution of electricity sales is provided in Exhibit 1-6. The change in electricity use varies over time by district, with some districts increasing their share as their decreases in electricity use are less than other those of other districts.

## Exhibit 1-6
## SALES OF ELECTRICITY BY REGION (GWh)

| Year | 1985 | 1986 | 1987 | 1988 | 1989 | 1990 | 1991 |
|---|---|---|---|---|---|---|---|
| Sofia City | 5,109 | 4,935 | 5,054 | 5,193 | 5,150 | 4,694 | 4,025 |
| Sofia District | 4,126 | 4,278 | 4,564 | 4,653 | 4,649 | 4,308 | 3,497 |
| Pleven | 4,723 | 4,671 | 5,025 | 5,049 | 4,773 | 4,914 | 4,199 |
| G. Oryahvitza | 4,069 | 3,926 | 4,196 | 4,373 | 4,319 | 4,096 | 3,493 |
| Varna | 4,743 | 4,614 | 4,523 | 4,694 | 4,626 | 4,335 | 3,629 |
| St. Zagora | 5,398 | 5,506 | 5,751 | 6,063 | 6,030 | 5,666 | 4,979 |
| Plovdiv | 6,269 | 6,244 | 6,583 | 6,671 | 6,723 | 6,494 | 5,579 |
| Total | 34,437 | 34,174 | 35,696 | 36,696 | 36,270 | 34,507 | 29,401 |

# 2. RESULTS OF INDUSTRIAL ENERGY SURVEY AND ENERGY AUDITS

## 2.1 INDUSTRIAL ENERGY SURVEY

A survey of the NEK's 106 largest electrical consumers was commissioned by RCG/Hagler, Bailly as part of the project. Hagler, Bailly subcontracted with Dimitar Baev - DBC, a private Bulgarian firm, to carry out the work.

### 2.1.1 Objective

The objective of the survey was to poll the 106 largest industrial electricity consumers with respect to their electricity consumption, business and economic activity, electrical generation at the facility (if any) and energy efficiency.

### 2.1.2 Activities

The project included the following tasks:

1) An English draft survey instrument was developed by Hagler, Bailly, and subsequently a Bulgarian version of the survey questionnaire by DBC, taking into account locally-accepted survey techniques by means of network of interviewers, as well as the recommendations of the experts from the Committee of Energy.

2) A test run of the survey was made in 7 enterprises in Sofia to verify that the survey instrument was acceptable. Based on the results, Hagler, Bailly determined that a two-stage methodology was required.

3) The survey instrument was distributed to the 106 largest electric consumers, and personal visits were made to each site in an attempt to achieve a high response rate to the survey.

4) For those who agreed to participate, on-site interviews were done by a nationwide network of interviewers (comprising over 20 interviewers) over the period November - December 1992.

5) A follow-up survey was conducted in the cooperating industries in December 1992 - January 1993 to obtain more quantitative data on energy consumption and production, and to evaluate the plant's attitudes toward energy conservation.

6) A data base was created containing the data from all the responses of the questionnaires.

7) Statistical analysis of the results was carried out by DBC.

8) Reports were prepared for both the main and the follow-up surveys by DBC, and provided to Hagler, Bailly and Committee of Energy.

### 2.1.3 Description of the survey

#### 2.1.3.1 Conditions in which the survey was conducted

The survey was influenced by number of factors, characteristic of the state of the Bulgarian economy and industry:

- deep economic recession, and decrease of the production;
- loss of most of Bulgaria's traditional markets and trading partners;
- de-monopolization and disintegration of old production structures;
- considerable increase in the percentage of unemployment;
- slow rates of the progress of restructuring of the economy and privatization;
- substantial decrease of state subsidies and increase of the debts of the enterprises.

During this period, Bulgaria was faced with particularly acute energy problems, including power outages. The period of the survey also coincided with government decisions for substantial increases in electricity tariffs and other energy prices.

Finally, another important fact should be taken into account - that in Bulgaria there is no tradition for conducting such surveys in industry.

#### 2.1.3.2 Survey interview techniques

The enterprises, subject to the survey are situated over the whole territory of Bulgaria, most of them being some distance from the large cities. From the point of view of the number of

questions as well as from the point of view of it's content, the study could be classified as technically complicated.

The officials which took part in the filling up of the questionnaires, were as follows:

- Top managers of the enterprises (general directors, executive directors);
- Deputy directors, responsible for the economics or production;
- Chief power engineering specialists, or Heads of departments "Power engineering";
- Heads of departments "Planning and Economics";
- Experts and specialists;

As a rule several of them took part successively in the responding of the questionnaires. The mean time to receive the full response was 15-20 days. During that time it was necessary for the interviewers to visit the enterprise several times in order to stimulate a response to the questionnaires.

From the total of 106 questionnaires send, 61 responded (57% rate), and 35 of these responded to the follow-up survey (33% response rate to full survey). In certain sectors of industry as coal mining, iron and steel, timber, construction and other branches the response rate was 100%. Of those who did not respond, some of the more important reasons were the following:

- The enterprises refuse in principle to accept questionnaires, because of the following motives:

  -- the questions represent firm's secrets;
  -- there are apprehensions of misuse of the information against the interests of the enterprise;
  -- essential structural and personnel changes are in progress;
  -- it is considered a priori that this is a pure waste of time.

  This group includes about 20 % of those who didn't answer.

- Enterprises which accepted the questionnaires, but didn't respond because of the following reasons:

  -- responding to the survey is of low priority, compared with the current operative tasks;

- -- it is impossible to create organization for joint completion of the questionnaires;
- -- fear of responsibility;
- -- during the progress of the filling up it is realized that more effort is necessary than originally considered;
- -- the questionnaire is left without control to somebody's working place, etc.

This group is the largest and includes about 75% of those who didn't answer.

- The enterprise said that the questionnaires were completed and sent to the interviewers by post, but were lost. This is about 5% of those not responding.

### 2.1.4 Summary of the Results

#### 2.1.4.1 Business and operating conditions

Exhibit 2-1 shows the results of part 1 of the survey, which was intended to summarize business conditions and operating characteristics. The exhibit shows each survey item and a summary of the responses, by percentage. The percentages do not add up to 100% in those cases in which one or more respondents did not answer an item or judged two choices equal.

As shown in Exhibit 2-1:

- Employment is in decline, and is expected to decline further in 48% of the sites;

- Plant capacity utilization declined significantly in 1991 (number of plants operating at 50% capacity or less went from 11% to 28%) and slightly in 1992 (35% of plants at 50% capacity or less), the largest declines were in the engineered products and chemicals/petroleum sectors;

- Capacity utilization is forecast to improve slightly in 1993 (only 20% at 50% capacity or less, with the food industry particularly optimistic);

- The principal factor required for recovery:

  - -- new markets (mentioned by 57%);
  - -- better management, efficiency, productivity or quality (20%);
  - -- new technology (14%);
  - -- supply of raw materials (14%);
  - -- higher prices (6%);
  - -- economic recovery (6%).

- Half of the plants have made significant investments in the past two years, and 43% expect to make significant investments in 1993 (metallurgy industries expect to invest, pulp & paper does not);
- Privatization is expected in the next two years by only 20% of the plants;
- Backlogs of manufacturing orders are fairly good, and inventories are not excessive;
- Most plants work multiple shifts - 17% have changed working hours since 1990, and 9% expect to change in 1993;
- Hours of operation correspond with NEK peaks, and 59% work 24 hours per day;
- Solving manufacturing problems (such as marketing, raw material supply, quality, and productivity) are judged higher priorities than energy cost reduction;
- Among energy costs, electricity was the highest priority.

EXHIBIT 2-1
BULGARIA
SURVEY OF LARGEST ELECTRICAL CONSUMERS
DECEMBER 1992 BY ET "DIMITAR BAEV – DBC"

PART 1 – SUMMARY OF OPERATIONS AND BUSINESS CONDITIONS

| HOW MANY NUMBER OF EMPLOYEES AT THIS FACILITY? | | | |
|---|---|---|---|
| less than 1000 | 1000–2000 | 2000–5000 | over 5000 |
| 38% | 32% | 18% | 5% |

| HOW HAS THE NUMBER OF EMPLOYEES CHANGED IN THE LAST YEAR? | | | | |
|---|---|---|---|---|
| | | reduced by: | reduced by: | reduced by: |
| same | increased | 5–10% | 10–20% | more than 20% |
| 21% | 9% | 39% | 11% | 13% |

| HOW DO YOU EXPECT THE NUMBER OF EMPLOYEES TO CHANGE OVER THE NEXT YEAR? | | | | |
|---|---|---|---|---|
| | | reduced by: | reduced by: | reduced by: |
| same | increased | 5–10% | 10–20% | more than 20% |
| 52% | 7% | 23% | 9% | 5% |

| WHAT IS THE BUSINESS OUTLOOK FOR YOUR INDUSTRIAL SECTOR? | | |
|---|---|---|
| optimistic | pessimistic | not clear |
| 46% | 2% | 46% |

| APPROXIMATELY WHAT PERCENT OF MAXIMUM CAPACITY DID YOUR ENTERPRISE PRODUCE? | | | | |
|---|---|---|---|---|
| Year | less than 25% | 25–50% | 51–75% | 76–100% |
| 1990 | 4% | 7% | 27% | 48% |
| 1991 | 7% | 21% | 41% | 18% |
| 1992 | 5% | 30% | 43% | 11% |

| APPROXIMATELY WHAT PERCENT OF MAXIMUM CAPACITY DOES YOUR ENTERPRISE EXPECT TO PRODUCE IN 1993? | | | |
|---|---|---|---|
| less than 25% | 25–50% | 51–75% | 76–100% |
| 0% | 20% | 41% | 21% |

| HAS YOUR ENTERPRISE MADE ANY SIGNIFICANT CAPITAL INVESTMENTS? | | |
|---|---|---|
| | Yes | No |
| In the last 2 years | 50% | 43% |
| In the last 6 months | 25% | 61% |

EXHIBIT 2-1
BULGARIA
SURVEY OF LARGEST ELECTRICAL CONSUMERS
DECEMBER 1992 BY ET "DIMITAR BAEV – DBC"

PART 1 – SUMMARY OF OPERATIONS AND BUSINESS CONDITIONS

| DOES YOUR ENTERPRISE PLAN TO MAKE SIGNIFICANT INVESTMENTS IN THE NEXT YEAR? | |
|---|---|
| Yes | No |
| 43% | 48% |

| WHEN DO YOU ANTICIPATE THAT THIS ENTERPRISE WILL BE PRIVATIZED? | | | | |
|---|---|---|---|---|
| already done | 0–12 months | 12–24 months | more than 24 months | not likely ever |
| 0% | 11% | 9% | 36% | 36% |

| APPROXIMATELY HOW LONG IS YOUR ENTERPRISE'S BACKLOG OF ORDERS? | | | | | |
|---|---|---|---|---|---|
| months of production at current production rate | | | | | |
| less than 1 | 1 – 2 | 2 – 4 | 4 – 6 | 6 – 9 | 9 – 12 |
| 11% | 20% | 11% | 6% | 11% | 6% |

| APPROXIMATELY HOW LARGE IS YOUR ENTERPRISE'S INVENTORY OF FINISHED PRODUCTS? | | | | | |
|---|---|---|---|---|---|
| months of production at current production rate | | | | | |
| less than 1 | 1 – 2 | 2 – 4 | 4 – 6 | 6 – 9 | 9 – 12 |
| 23% | 17% | 6% | 0% | 0% | 3% |

| HOW DOES THE ENTERPRISE OPERATE DURING THE DAY? | | |
|---|---|---|
| 24 hours/day | 2 shifts | 1 shift |
| 59% | 29% | 13% |

| HOW MANY HOURS PER WEEK DOES THE MAIN PRODUCTION PROCESS OPERATE? | | | | | | |
|---|---|---|---|---|---|---|
| less than 24 | 24–48 | 48–72 | 72–96 | 96–120 | 120–144 | 144–168 |
| 9% | 17% | 9% | 12% | 3% | 9% | 41% |

EXHIBIT 2-1
BULGARIA
SURVEY OF LARGEST ELECTRICAL CONSUMERS
DECEMBER 1992 BY ET "DIMITAR BAEV – DBC"

PART 1 – SUMMARY OF OPERATIONS AND BUSINESS CONDITIONS

WHAT ARE THE HOURS OF OPERATION OF THE PRODUCTION PROCESS AT YOUR ENTERPRISE?

| hours of operation | Monday | Tuesday | Wednesday | Thursday | Friday | Saturday | Sunday |
|---|---|---|---|---|---|---|---|
| 0 – 1 | 62% | 65% | 65% | 65% | 65% | 59% | 56% |
| 1 – 2 | 62% | 65% | 65% | 65% | 65% | 59% | 56% |
| 2 – 3 | 62% | 65% | 65% | 65% | 65% | 59% | 56% |
| 3 – 4 | 62% | 65% | 65% | 65% | 65% | 59% | 56% |
| 4 – 5 | 62% | 65% | 65% | 65% | 65% | 59% | 56% |
| 5 – 6 | 68% | 71% | 71% | 71% | 71% | 62% | 59% |
| 6 – 7 | 76% | 76% | 76% | 76% | 76% | 65% | 65% |
| 7 – 8 | 82% | 82% | 82% | 82% | 82% | 68% | 68% |
| 8 – 9 | 100% | 100% | 100% | 100% | 100% | 74% | 68% |
| 9 – 10 | 100% | 100% | 100% | 100% | 100% | 74% | 68% |
| 10 – 11 | 100% | 100% | 100% | 100% | 100% | 74% | 68% |
| 11 – 12 | 100% | 100% | 100% | 100% | 100% | 74% | 68% |
| 12 – 13 | 100% | 100% | 100% | 100% | 100% | 74% | 68% |
| 13 – 14 | 100% | 100% | 100% | 100% | 100% | 71% | 68% |
| 14 – 15 | 100% | 100% | 100% | 100% | 100% | 71% | 68% |
| 15 – 16 | 100% | 100% | 100% | 100% | 100% | 71% | 68% |
| 16 – 17 | 91% | 91% | 91% | 91% | 91% | 71% | 68% |
| 17 – 18 | 79% | 79% | 79% | 79% | 79% | 65% | 65% |
| 18 – 19 | 79% | 79% | 79% | 79% | 79% | 65% | 65% |
| 19 – 20 | 79% | 79% | 79% | 79% | 79% | 65% | 65% |
| 20 – 21 | 79% | 79% | 79% | 79% | 79% | 65% | 65% |
| 21 – 22 | 76% | 76% | 76% | 76% | 76% | 62% | 62% |
| 22 – 23 | 74% | 74% | 74% | 74% | 74% | 62% | 62% |
| 23 – 24 | 71% | 71% | 71% | 71% | 71% | 62% | 62% |

HAVE THERE BEEN ANY CHANGES TO THESE HOURS SINCE 1990?

| Yes | No |
|---|---|
| 17% | 77% |

DO YOU EXPECT ANY CHANGES TO THESE HOURS IN 1993?

| Yes | No |
|---|---|
| [illegible]% | [illegible]% |

EXHIBIT 2-1
BULGARIA
SURVEY OF LARGEST ELECTRICAL CONSUMERS
DECEMBER 1992 BY ET "DIMITAR BAEV – DBC"

PART 1 – SUMMARY OF OPERATIONS AND BUSINESS CONDITIONS

WHAT ARE NOW THE SHORT-TERM PRIORITIES IN YOUR ENTERPRISE?

| | Percentage who ranked it (5 is top priority) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Description of the problem | 5 | 4 | 3 | 2 | 1 | 0 | Score | Rank |
| Finding a way to sell more of our finished products | 63% | 14% | 6% | 3% | 3% | 11% | 3.97 | 1 |
| Obtaining reliable sources of raw materials | 34% | 20% | 3% | 11% | 6% | 26% | 2.89 | 2 |
| Reducing the cost of production, not including energy | 26% | 14% | 23% | 11% | 6% | 20% | 2.83 | 3 |
| Improving the quality of our products | 20% | 17% | 17% | 9% | 0% | 37% | 2.37 | 4 |
| Reducing the cost of electric energy | 17% | 20% | 14% | 9% | 3% | 37% | 2.29 | 5 |
| Managing people and improving labor productivity | 20% | 6% | 26% | 9% | 9% | 31% | 2.26 | 6 |
| Maintaining our equipment, reducing break-downs | 14% | 14% | 26% | 3% | 3% | 40% | 2.14 | 7 |
| Reducing the cost of fuel energy | 14% | 17% | 11% | 14% | 6% | 37% | 2.09 | 8 |
| Reducing pollution, improving ecology | 17% | 11% | 11% | 17% | 6% | 37% | 2.06 | 9 |
| Obtaining reliable sources of electric energy | 9% | 11% | 20% | 11% | 3% | 46% | 1.74 | 10 |
| Dealing with inefficient government bureacracy | 11% | 6% | 23% | 9% | 0% | 51% | 1.66 | 11 |
| Reducing the cost of heat energy | 6% | 17% | 17% | 6% | 3% | 51% | 1.63 | 12 |
| Privatizing our plant | 9% | 11% | 23% | 0% | 3% | 54% | 1.60 | 13 |
| Changing our plant to produce different products | 6% | 11% | 14% | 11% | 6% | 51% | 1.46 | 14 |
| Obtaining reliable sources of heat energy | 14% | 6% | 0% | 11% | 6% | 63% | 1.23 | 15 |
| Reducing operations to meet the market conditions | 3% | 6% | 17% | 11% | 3% | 60% | 1.14 | 16 |
| Obtainining reliable sources of fuel energy | 0% | 14% | 9% | 6% | 11% | 60% | 1.06 | 17 |
| Other | 3% | 0% | 0% | 3% | 0% | 94% | 0.20 | 18 |

### 2.1.4.2 Current and projected electricity usage

Exhibit 2-2 shows the results of part 2 of the survey, which concerned electricity usage. Again, the exhibit shows each survey item and a summary of the responses, by percentage. The percentages do not add up to 100% in those cases in which one or more respondents did not answer an item.

As shown in Exhibit 2-2:

- 83% of the sites have a load of 10 MW or more;
- 1992 electricity consumption was reduced from 1991 in 46% of the plants;
- 1992 reductions were significant (10% or more) in 31% of the plants, and very large (20% or more) in 20% of the plants;
- 1993 electricity consumption and peak usage is forecast to be the same as 1992, or higher, in 91% of the plants;
- Peak demand (MW) seems be about the same as day MW;
- Reductions in peak demand have been significantly less than reductions in energy consumption, and this trend is expected to continue;
- The expected changes in electricity consumption are well correlated with the expected changes in production;

EXHIBIT 2-2
BULGARIA
SURVEY OF LARGEST ELECTRICAL CONSUMERS
DECEMBER 1992 BY ET "DIMITAR BAEV – DBC"

PART 2 – CURRENT AND PROJECTED ELECTRIC ENERGY USAGE

WHAT IS THE ELECTRIC ENERGY CONSUMPTION FOR YOUR ENTERPRISE FOR 1992?

| | Gigawatt-hours (GWh): | | | | |
|---|---|---|---|---|---|
| Period: | less than 2 | 2 – 5 | 5 – 10 | 10 – 20 | 20 or more |
| peak GWh | 9% | 51% | 17% | 9% | 11% |
| day GWh | 3% | 14% | 34% | 23% | 23% |
| night GWh | 14% | 40% | 9% | 20% | 14% |
| TOTAL GWh | 3% | 0% | 11% | 40% | 43% |

HOW IS YOUR ELECTRIC ENERGY CONSUMPTION DISTRIBUTED FOR 1992?

| Peak energy | Day energy | Night energy |
|---|---|---|
| 22% | 45% | 32% |

HOW HAS THE TOTAL ELECTRIC ENERGY CONSUMPTION CHANGED IN COMPARISON WITH 1991?

| CHANGE | the same | increased by... | decreased by... |
|---|---|---|---|
| 0 | 31% | | |
| 1-5% | | 6% | 14% |
| 5-10% | | 0% | 0% |
| 10-20% | | 6% | 11% |
| 20-50% | | 9% | 17% |
| > 50% | | 0% | 3% |
| TOTAL | 31% | 20% | 46% |

HOW DO YOU EXPECT THE TOTAL ELECTRIC ENERGY CONSUMPTION TO CHANGE IN 1993, COMPARED WITH 1992?

| CHANGE | the same | to increase by... | to decrease... |
|---|---|---|---|
| 0 | 51% | | |
| 1-5% | | 11% | 0% |
| 5-10% | | 3% | 0% |
| 10-20% | | 6% | 3% |
| 20-50% | | 11% | 6% |
| > 50% | | 9% | 0% |
| TOTAL | 51% | 40% | 9% |

EXHIBIT 2–2
BULGARIA
SURVEY OF LARGEST ELECTRICAL CONSUMERS
DECEMBER 1992 BY ET "DIMITAR BAEV – DBC"

PART 2 – CURRENT AND PROJECTED ELECTRIC ENERGY USAGE

HOW DID THE ENERGY CONSUMPTION DURING PEAK HOURS CHANGE IN 1992, COMPARED WITH 1991?

| CHANGE | the same | increased by... | decreased by... |
|---|---|---|---|
| 0 | 29% | | |
| 1–5% | | 9% | 0% |
| 5–10% | | 9% | 3% |
| 10–20% | | 9% | 6% |
| 20–50% | | 14% | 14% |
| > 50% | | 6% | 3% |
| TOTAL | 29% | 47% | 26% |

HOW DO YOU EXPECT THE ENERGY CONSUMPTION DURING PEAK HOURS TO CHANGE IN 1993, COMPARED WITH 1992?

| CHANGE | the same | to increase by... | to decrease by... |
|---|---|---|---|
| 0 | 51% | | |
| 1–5% | | 9% | 0% |
| 5–10% | | 6% | 0% |
| 10–20% | | 3% | 6% |
| 20–50% | | 20% | 0% |
| > 50% | | 3% | 0% |
| TOTAL | 51% | 41% | 6% |

CORRELATION OF RESPONSES TO QUESTIONS ON ENERGY USAGE AND PRODUCTION:
HOW DO YOU EXPECT THE LEVEL OF PRODUCTION OUTPUT TO CHANGE IN 1993?
HOW DO YOU EXPECT THE TOTAL ELECTRIC ENERGY CONSUMPTION TO CHANGE IN 1993?

| | Electric energy consumption: | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Production Output: | the same | up 1–10% | up 10–20% | up > 20% | down 1–10% | down 10–20% | down > 20% | TOTAL |
| the same | 73% | 9% | 9% | 9% | 0% | 0% | 0% | 31% |
| up 1–10% | 33% | 33% | 17% | 17% | 0% | 0% | 0% | 17% |
| up 10–20% | 57% | 14% | 0% | 14% | 0% | 0% | 14% | 20% |
| up more than 20% | 29% | 0% | 0% | 57% | 0% | 0% | 14% | 20% |
| down 1–10% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% |
| down 10–20% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% |
| down more than 20% | 0% | 50% | 0% | 0% | 0% | 50% | 0% | 6% |
| TOTAL | [illegible] | [illegible] | [illegible] | 20[illegible] | 0[illegible] | [illegible]3% | [illegible]% | [illegible] |

EXHIBIT 2-2
BULGARIA
SURVEY OF LARGEST ELECTRICAL CONSUMERS
DECEMBER 1992 BY ET "DIMITAR BAEV – DBC"

PART 2 – CURRENT AND PROJECTED ELECTRIC ENERGY USAGE

WHAT IS THE MAXIMUM ELECTRIC POWER DEMAND FOR YOUR ENTERPRISE FOR 1992?

| | Megawatts: | | | | |
|---|---|---|---|---|---|
| Period: | 0 – 5 | 5 – 10 | 10 – 20 | 20 – 50 | 50 or more |
| peak MW | 29% | 39% | 6% | 6% | 6% |
| day MW | 32% | 32% | 10% | 6% | 3% |
| night MW | 42% | 23% | 10% | 6% | 3% |

HOW DID THE MAXIMUM DEMAND (MW) CHANGE IN 1992, COMPARED WITH 1991?

| CHANGE | the same | increased by... | decreased by... |
|---|---|---|---|
| 0 | 51% | | |
| 1–5% | | 3% | 0% |
| 5–10% | | 3% | 3% |
| 10–20% | | 6% | 9% |
| 20–50% | | 6% | 14% |
| > 50% | | 0% | 0% |
| TOTAL | 51% | 18% | 26% |

HOW DO YOU EXPECT THE MAXIMUM DEMAND (MW) TO CHANGE IN 1993, COMPARED WITH 1992?

| CHANGE | the same | to increase by... | to decrease by... |
|---|---|---|---|
| 0 | 63% | | |
| 1–5% | | 6% | 0% |
| 5–10% | | 3% | 0% |
| 10–20% | | 9% | 3% |
| 20–50% | | 11% | 3% |
| > 50% | | 0% | 0% |
| TOTAL | 63% | 29% | 6% |

EXHIBIT 2–2
BULGARIA
SURVEY OF LARGEST ELECTRICAL CONSUMERS
DECEMBER 1992 BY ET "DIMITAR BAEV – DBC"

PART 2 – CURRENT AND PROJECTED ELECTRIC ENERGY USAGE

WHAT IS YOUR ESTIMATED COST FOR PURCHASED ENERGY 1992?
MILLIONS OF LEVA

| | 0–5 | 5–10 | 10–20 | 20–50 | 50–100 | more than 100 | no answer |
|---|---|---|---|---|---|---|---|
| Electricity | 3% | 23% | 23% | 17% | 6% | 6% | 23% |
| Heat | 6% | 9% | 0% | 3% | 0% | 0% | 83% |
| Gas | 9% | 6% | 9% | 3% | 0% | 3% | 71% |
| Oil | 14% | 6% | 14% | 3% | 6% | 3% | 54% |
| Coal | 14% | 0% | 0% | 3% | 0% | 0% | 83% |

### 2.1.4.3 Equipment installed for electricity generation and use

Exhibit 2-3 shows the results of part 3 of the survey, which concerned equipment available for power generation, and principal electricity using equipment. Again, the exhibit shows each survey item and a summary of the responses, by percentage. The percentages do not add up to 100% in those cases in which one or more respondents did not answer an item.

According to NEK, Bulgaria now has nine large industrial cogenerators (with capacities of 20 MW or greater). Six of the 61 plants surveyed can generate their own electricity, but the survey discovered that two of these do not operate their generators regularly.

As shown in Exhibit 2-3:

- Six of the plants responding have a generator, of these three are in the chemicals and petroleum sector, two in non-ferrous metals and one in glass;
- Of those six that have a generator, two do not operate regularly, but probably could do so;
- Among those six that have a generator, only half felt that the purchase price of power paid by NEK is too low;
- Among those six that have a generator, the following reasons were given for not increasing the output:
  - -- three (50%) said they were at their technical potential;
  - -- one said because of the reduced production rate;
  - -- one said because of low electricity prices;
  - -- one said because of lack of fuel.
- Among those that do not have a generator, only 2% considered it possible to install one (25% no answer or did not know);
- Motors driving pumps, fans, compressors, and other equipment were cited as primary loads by 77% of the respondents;
- Less than half of the plants use efficient lighting systems (sodium vapor, metal halide, or compact fluorescent).
- For the specific process equipment identified (some of which are relevant only to specific industrial sectors), the following totals were developed:
  - -- electrolysis (chemicals) 27 MW



252

| | | |
|---|---|---|
| -- | heat treatment (metals) | 25 MW |
| -- | rolling mills (metals) | 24 MW |
| -- | compressors | 20 MW |
| -- | electric furnaces (metals) | 18 MW |
| -- | water pumps | 16 MW |
| -- | catalytic cracking (petroleum) | 15 MW |
| -- | motors for other uses | 15 MW |
| -- | machine tools (engineered products) | 11 MW |
| -- | fans | 10 MW |

EXHIBIT 2-3
BULGARIA
SURVEY OF LARGEST ELECTRICAL CONSUMERS
DECEMBER 1992 BY ET "DIMITAR BAEV – DBC"

PART 3 – EQUIPMENT INSTALLED FOR ELECTRICITY GENERATION AND USE

| IS THERE AN ELECTRIC GENERATOR AT THIS FACILITY? | |
|---|---|
| Yes | No |
| 11% | 88% |

| IF SO, DOES THE GENERATOR OPERATE REGULARLY? | |
|---|---|
| Yes | No |
| 67% | 33% |

| (FOR THOSE WHO HAVE A GENERATOR) IS THE PRICE PAID BY NEK FOR PURCHASED POWER TOO LOW? | |
|---|---|
| Yes | No |
| 50% | 50% |

| IS THERE A POSSIBILITY OF INCREASING THE OUTPUT OF YOUR EXISTING GENERATOR? | |
|---|---|
| Yes | No |
| 33% | 67% |

| IS THERE A SIGNIFICANT REQUIREMENT FOR STEAM OR HOT WATER AT YOUR FACILITY? | |
|---|---|
| Yes | No |
| 71% | 14% |

| IF YOU DO NOT HAVE A GENERATOR, IS IT POSSIBLE TO INSTALL ONE? | |
|---|---|
| Yes | No |
| 2% | 73% |

| WHAT ARE THE PRIMARY CONSUMERS OF ELECTRIC ENERGY IN YOUR ENTERPRISE? | |
|---|---|
| | Mentioned by: |
| Motors driving pumps, fans, compressors | 77% |
| Lighting | 61% |
| Electric heating, furnaces, boilers | 52% |
| Welding | 34% |
| Machine tools, metal working | 25% |
| Electrochemical processes | 14% |
| Refrigeration | 11% |
| Other | 7% |

EXHIBIT 2–3
BULGARIA
SURVEY OF LARGEST ELECTRICAL CONSUMERS
DECEMBER 1992 BY ET "DIMITAR BAEV – DBC"

PART 3 – EQUIPMENT INSTALLED FOR ELECTRICITY GENERATION AND USE

| WHAT TYPES OF LIGHTS ARE USED AT YOUR ENTERPRISE? | Mentioned by: |
|---|---|
| Fluorescent | 89% |
| Incandescent | 86% |
| Mercury vapor | 75% |
| Sodium vapor | 45% |
| Metal halide | 27% |
| Compact fluorescent | 14% |
| Other | 0% |

### 2.1.4.4 Energy conservation experience, opportunities, and attitudes

Exhibit 2-4 shows the results of part 4 of the survey, which concerned energy conservation. Again, the exhibit shows each survey item and a summary of the responses, by percentage. The percentages do not add up to 100% in those cases in which one or more respondents did not answer an item.

As shown in Exhibit 2-4:

- Some 13% of plants could curtail usage during peak periods a significant amount, and another 50% could reduce slightly;

- Some 77% are interested in pursuing energy conservation opportunities in their plant;

- 69% of the respondents are aware of ideas to improve energy efficiency, the measures could be grouped in the following way:

  -- expedient technological changes and improvements (65% of respondents);
  -- improvements in lighting systems and controls (20%);
  -- correct operations of production processes, such as loading of equipment and coordination of energy consumers (20%);
  -- measures for improvement of cos Φ (power factor) (9%);

- The reasons why these improvements have not yet been implemented are:

  -- lack or scarcity of funds, finances (53% of respondents);
  -- production process limitations, such as continuous operations (25%);
  -- lack of incentives, existing energy prices (9%);
  -- lack of suitable organization (6%);
  -- lack of suitable projects (6%);

- About half the plants are willing to invest in energy efficiency projects, including borrowing from a bank if necessary;

- Energy audits have been conducted in 50% of the enterprises:

  -- 58% of audits were conducted by external organizations (institutes and design organizations in energetics and automation),
  -- 27% were conducted by specialists of the enterprises themselves,
  -- 15% were joint studies by external organizations and specialists from the enterprise.

- Of the plants that had energy audits, 6% were completely satisfied with the results, 62% found the audits to be partially satisfactory, and 28% found the audit to be useless;

- 70% of the plants would be willing to participate in an energy audit program financed by COE or NEK, and 14% refuse;

- 42% of the plants would be willing to hire an energy auditor (and about one-quarter of these had already done so);

- Only 14% of the plants were aware of any energy efficiency activities in Bulgaria by Western experts.

EXHIBIT 2–4
BULGARIA
SURVEY OF LARGEST ELECTRICAL CONSUMERS
DECEMBER 1992 BY ET "DIMITAR BAEV – DBC"

PART 4 – ENERGY CONSERVATION EXPERIENCE, OPPORTUNITIES AND ATTITUDES

| COULD THE ENTERPRISE CURTAIL ALL OR PART OF ITS ELECTRICAL USE DURING PEAK PERIODS? | | |
|---|---|---|
| Yes, significant amount | Yes, a little | None at all |
| 13% | 50% | 34% |

| COULD THE ENTERPRISE SWITCH SOME OF ITS ELECTRICAL USAGE TO FUELS? | | |
|---|---|---|
| Yes, significant amount | Yes, a little | None at all |
| 13% | 20% | 68% |

| DO YOU KNOW OR EXPECT THAT THERE ARE OTHER ENERGY EFFICIENCY MEASURES APPLICABLE TO YOUR FACILITY? | | |
|---|---|---|
| Yes, significant amount | Yes, a little | None at all |
| 14% | 55% | 29% |

| WOULD YOU BE INTERESTED IN IMPLEMENTING ENERGY EFFICIENCY MEASURES AT YOUR FACILITY | | |
|---|---|---|
| Yes, very interested | Yes, somewhat interested | No |
| 50% | 27% | 9% |

| WOULD YOU MAKE THE EXPENDITURE REQUIRED FOR ENERGY SAVING PROJECTS? | |
|---|---|
| Yes | 49% |
| No, we have no money available | 34% |
| No, we have other priorities for our money | 9% |

| WOULD YOU BORROW MONEY FROM A BANK TO INVEST IN AN ENERGY EFFICIENCY PROJECT? | |
|---|---|
| Yes, we have already done this | 9% |
| Yes, but we need help to arrange credit | 23% |
| Yes, but we don't know of any appropriate investment projects | 20% |
| No, we have other priorities for investment | 40% |

| WOULD YOU BE INTERESTED IN LEARNING MORE ABOUT WAYS TO REDUCE ENERGY COSTS? | | | |
|---|---|---|---|
| Yes, very interested | Yes, somewhat | No, energy is low priority | No, we already know how |
| 57% | 29% | 3% | 6% |

| HAS AN ENERGY AUDIT BEEN CONDUCTED AT YOUR ENTERPRISE? | |
|---|---|
| Yes | No |
| 50% | 46% |

EXHIBIT 2-4
BULGARIA
SURVEY OF LARGEST ELECTRICAL CONSUMERS
DECEMBER 1992 BY ET "DIMITAR BAEV – DBC"

PART 4 – ENERGY CONSERVATION EXPERIENCE, OPPORTUNITIES AND ATTITUDES

| IF YOUR PLANT HAS RECIEVED AN ENERGY AUDIT, HOW SATISFACTORY WERE THE RESULTS? | |
|---|---|
| Yes, we had energy audit and are absolutely satisfied | 3% |
| Yes, we had energy audit and are partially satisfied | 31% |
| Yes, we had energy audits, and it turned out to be useless | 14% |
| No, we have not had an energy audit | 46% |

| WOULD YOU BE INTERESTED AN ENERGY AUDIT PAID FOR BY COE/NEK? | | |
|---|---|---|
| Yes | No | Maybe |
| 70% | 14% | 14% |

| WOULD YOUR FIRM BE WILLING TO PAY FOR ENERGY AUDIT BY BULGARIAN EXPERTS? | |
|---|---|
| Yes, in fact we already hired someone | 11% |
| Yes, we would pay a market price | 31% |
| No, only if we can get it at no cost | 31% |
| No, not interested in an energy audit | 17% |

| ARE YOU AWARE OF ANY ENERGY EFFICIENCY PROGRAMS CARRIED OUT IN BULGARIA BY FOREIGN EXPERTS? | |
|---|---|
| Yes | No |
| 14% | 80% |

| DID YOU HEAR ABOUT THE 1991 INDUSTRIAL ENERGY EFFICIENCY PROGRAM IN BULGARIA SPONSORED BY USAID? | |
|---|---|
| Yes | No |
| 3% | 89% |

## 2.2 RESULTS OF ENERGY AUDITS IN BULGARIA

Under funding provided by the USAID Emergency Energy Project, energy audits were carried out in eight industrial enterprises in Bulgaria in 1991 by International Resources Group (IRG) of Washington DC. The enterprises audited were:

- Kremikovtzi Steel Company, Cold Rolling Mill (iron & steel sector)
- Serdika Milk Processing Plant (food processing)
- "Pharmacia" Company, Stanke Dimitrov (pharmaceuticals)
- Izida Ceramic Works (ceramics)
- Dobritch Poultry Company (food processing)
- "Parvi Mai" Textile Mill, Varna (textiles)
- Devnia Soda Ash Plant (mineral processing)
- Chimco Ammonia and Urea Plant (petrochemical fertilizer)

The scope of these audits focussed on thermal energy, not electricity, however general findings are expected to be similar. The summary findings of IRG are quoted below[1]

> Attention to energy conservation varied widely; however energy inefficiency was evident in every plant. The inefficiencies exist for a number of reasons. Lack of instrumentation required for effective energy monitoring and the use of inherently inefficient Eastern Bloc technologies are two main causes of industrial energy inefficiency. Equally important, subsidized energy inputs into the production process have historically discouraged efficient energy use. Moreover, until the initiation of the Emergency Energy Program, with its emphasis on energy efficiency, managers in all the demonstration plants were too overwhelmed with the pace and magnitude of economic changes to devote adequate time and consideration to any single problem, including energy efficiency.
>
> Neither management nor technical staff were given guidance or encouragement on energy efficiency from the previous regime, and consequently they were simply unaware of the magnitude of easily preventable energy losses. With the demise of the former government, myopic production considerations ceased to be the focus of enterprise

[1] "Industry Profile Report - Bulgaria", May 1992, for U.S. AID by International Resources Group, Washington DC.

management. Instead, efficiency and profitability, hallmarks of free market economies, gained transcendence.

Communication in large organizations is rarely as effective as needed under the best of circumstances. The legacy of central planning and single party rule, with its emphasis on idealogy, has further complicated the communication process, by making Bulgarian workers eager to "keep a low profile and not make waves."

The demonstration plants were organized along functional lines, with production/ operations, maintenance, packing and shipping, finance, utilities, engineering/technical services, and administrative/purchasing divisions. However, these enterprises differed from Western organizations insofar as they did not have internal sales or marketing divisions, since this function was handled by separate large state-owned trading companies. Since 1990, enterprise managers, previously concerned only with production, were forced to expand their marketing functions, despite relative inexperience in this area. Consequently, marketing became a high management priority in nearly every production plant.

State-owned companies and plants in Bulgaria historically were not subject to complete financial accountability, owing to government subsidies. Consequently, they had less incentive to save energy. Although the situation has now changed, and energy efficiency is an important factor in economic survival, Bulgarian managers have largely ignored the potential for low-cost and no-cost energy savings measures. To some extent, this inaction is the lack of awareness of the magnitude of avoidable energy (and financial) losses due to energy efficiency.

Even in instances where industrial managers and technical staff are aware of the importance of efficient energy use, institutional issues have inhibited widespread improvement in energy efficiency. Lack of financial resources (local or hard currency) and the lack of availability of most instrumentation needed for energy audits, monitoring and control, have made the purchase of even inexpensive monitoring equipment and capital intensive control systems difficult for most plants.

Moreover, industrial management inexperience with investment decision-making can result in haphazard use of investment resources that are available. Standardized investment decision-making practices are rare and inadequate. Industrial decision-makers in Bulgaria do not have sufficient understanding of the value of small energy saving initiatives, and are more interested in complex technologies. Overall, managers have not, until recently (the energy audits and in-part training programs made managers aware of the costs of energy) been aware of the magnitude of the value of what appeared to be small energy losses. For example, few plants gave any consideration to the effective

performance of steam traps or to steam condensate recovery programs[2], both of which are low-cost, high payback initiatives.

Owing to increased awareness of the importance of small energy losses, managers at all the demonstration plants have become very interested in analyzing and implementing smaller-scale, low cost energy conservation initiatives. However, efforts to promote a "efficiency ethic" have been limited, and little attention is given to basic measures such as keeping furnace doors, building doors and windows closed and turning out lights in vacant rooms. Few effective energy management programs exit in Bulgaria, again owing to the lack of equipment availability and lack of management understanding of the benefits of energy management. Ultimately, however, economic survival imperatives, combined with increasing energy prices, will promote increased interest in energy saving initiatives throughout Bulgaria.

[2] Hagler, Bailly expects that similar situations exist for electrical energy; one example would be the use of motors which are too large for the actual load.

## 2.3 FINDINGS OF ENERGY AUDITS IN OTHER EASTERN EUROPEAN COUNTRIES

Since 1991, Hagler, Bailly has carried out management, technical and energy audits in more than 30 industrial enterprises in the region (in Hungary and Yugoslavia in 1991 and Latvia, Estonia, and Russia in 1992, and Poland in 1993). In the project in Hungary, factories carried out process changes, management changes, and organization changes that led to energy cost savings of more than $1 million per year in several cases. Measured improvements to the ratio of energy to production quantity of more than 30% was achieved in one factory and more than 20% in another factory, both at the same production level. In addition, traditional heat and power energy saving projects were carried out which saved 5-10% in several factories.

Since 1992, Hagler, Bailly has been conducting the Industrial Energy Efficiency project in Bulgaria on behalf of USAID, as a follow-up to the 1991 Emergency Energy Project. We recognize that there are significant differences between Bulgaria and other countries, however we have also observed similarities in technology and management approaches. This section summarizes technical findings from work in many countries in the region, with notes on their relevance to electricity demand management in Bulgaria.

Any improvements in energy efficiency can only be achieved by taking specific, detailed actions. These actions involve changes to operations, maintenance, or equipment. Some actions may cost nothing, and others may require million dollar investments. An energy efficiency program typically involves 10-20 actions, each of which improve efficiency by 1-2%.

Achieving and maintaining good energy efficiency in an enterprise is a never-ending process, and must be fully integrated into the normal course of business operations. The standard of efficiency is always increasing over time, as dictated by the competition in any given market.

There are many techniques for improving industrial energy efficiency, but these are often simplified by categorizing them in groups, on the basis of the investment required:

A. Management and organizational improvements, which generally require little or no investment;

B. Low-cost measures to improve operations and maintenance, projects which provide a payback of one year or less;

C. Minor investments to upgrade existing equipment, projects which provide a payback of two years or less, based on energy savings;

D. Major investments to acquire new, modern equipment, which should provide multiple benefits in productivity, quality, and energy efficiency.

### 2.3.1 Examples of "Type A" Actions, Management and Organizational Improvements

- Hire professionals with expertise in the specific industrial process to work together with plant senior staff (General Director, Economics Director, Technical Director) to carry out a "management audit", an executive review of the production organization, management, marketing, accounting, finance, operations, and investment program to identify ways to reduce costs and improve productivity, efficiency and quality. Use the results of this audit to develop an action plan.

- Change ownership so that a new "owner's mentality" and sense of purpose for the future is created. The owner must establish a management commitment to quality, productivity and efficiency. The owner may take an active approach to seek out foreign joint venture partners.

- Change organizational structure to place responsibility for energy efficiency (including identification and implementation of energy saving ideas and projects) at the production department, where most energy is consumed. Two possible approaches to do this:

  -- make the energy department subordinate to production, like other suppliers of raw materials;

  -- if a cogeneration facility exists, establish energy department as a profit center, "selling" energy to production department.

- Establish energy accounting systems and management information systems to allow management to monitor efficiency in time to take control actions.

- Create working conditions that motivate all employees (especially those in the production departments) to improve efficiency, productivity and quality, including financial incentives and feedback of results.

- Provide information and training appropriate to employees at management and engineering levels in energy efficiency technology and techniques.

- Establish a "total" quality and efficiency management program in the plant, based on employee participation in a process of continuous improvement based on planning, testing, action, feedback of results, and refinement.

- Organize a market-driven decision-making process for difficult, but essential, management decisions which are urgently required, but are being delayed, such as:

- -- Which markets to be in
- -- Which products to produce
- -- Level of quality needed by the market
- -- Type of packaging needed by the market
- -- Transportation needed to get to the market in time
- -- Which parts of the plant are obsolete and must be closed

- Establish a marketing department with sufficient staffing and funding[3] to increase sales, so that the plant can operate at higher capacity factor, and thereby spread fixed energy consumption over more units of production.

- Establish a production process R&D department to learn the state-of-the-art in the selected markets/products, and plan the future modernization of the plant. Provide a budget for experts to carry out market research and feasibility studies[4].

- Optimize operations, so that production is carried out using the most efficient equipment in the factory in the most efficient way (least-cost production).

### 2.3.2 Examples of "Type B" Actions, Low-Cost Improvements to Operations and Maintenance

- Hire professionals with expertise in the specific industrial process to work together with plant senior staff (Technical Director, Chief Engineer) to carry out a "technical audit", an engineering and economic review of the production operations, technology, maintenance, and investment program to identify opportunities to reduce costs and improve productivity, efficiency, and quality. Use the results of this audit to develop an action plan.

- Hire professionals with expertise in industrial energy conservation to work together with plant senior staff (Chief Energetics) carry out an "electrical energy audit", an engineering and economic review of the plant electrical systems and equipment to identify opportunities to reduce energy cost. Use the results of this audit to develop an action plan.

- Upgrade the general standard of maintenance throughout the plant, and provide maintenance personnel with tools, training, status, and management reinforcement to carry out the job.

---

[3] Many western companies spend 20% of revenues, or more, on marketing.

[4] Many Western companies allocate 10% of revenues to R&D and new product development.

- Establish teams dedicated to specific efficiency-related tasks on electrical equipment such as lighting, motors, drive systems, rotating equipment (pumps, fans, compressors), and piping systems for compressed air, water, and refrigeration. Provide these teams with the necessary diagnostic instruments, repair tools, and budgets. These teams will have several tasks:

  -- To identify obvious energy waste, such as leaks, idling equipment or underloaded operations, and carry out necessary repairs.
  -- To identify low-cost improvements to operations and maintenance, and to establish new procedures.
  -- To identify minor retrofit improvements needed, and to develop cost and benefit estimates
  -- To develop specifications for future procurement, and thereby upgrade the standard of efficiency over time.

- Upgrade the level of instrumentation in the plant, especially for energy flows and efficiency-related parameters, and establish procedures based on instrument readings.

- Establish a preventive maintenance system in the plant, with necessary monitoring instruments, procedures, and dedicated staff, to improve equipment reliability (reduce downtime) and thereby increase efficiency.

- Provide information and training in energy efficiency technology and techniques, appropriate to employees at various production, operations and maintenance levels.

### 2.3.3 Examples of "Type C" Projects, Minor Investments in Equipment Upgrading

- Improve quality control equipment to reduce scrap generated by production process.

- Install recycling equipment to convert scrap generated at intermediate stages of the process.

- Rehabilitate electric furnaces and heat exchangers to clean radiant and convective heat transfer surfaces and repair casing leaks.

- Rehabilitate process equipment to improve reliability and reduce start/stops and downtime.

- Install efficient lighting systems, variable speed drives and other cost-effective retrofits where feasible.

### 2.3.4 Examples of "Type D" Projects, Capital Investments in Modernization

- Convert the plant to produce a different, but related, product that offers a higher value-added for a given level of energy consumption.

- Install new process technology for the same product to improve productivity, increase reliability, improve quality, and reduce specific energy consumption.

- Install new motors, turbines, and prime movers that offer higher efficiency.

- Install cogeneration (combined heat and power systems), possibly sized to generate excess power for sale to NEK grid or sale of heat to the neighboring district.

## 3. BULGARIA ELECTRICITY DEMAND FORECAST

Several forecasts of electricity demand in Bulgaria have been completed over the past several years. Prior forecasts differ because of differences in scenarios, differences in forecasting techniques, and differences in data. However, the more recent forecasts that build on the data obtained after the initiation of Bulgaria's transition to a market economy will more accurately capture the Bulgarian economy's energy response to this transition and the probable future of electricity demand.

The forecasts are summarized graphically in Exhibit 3-1, and described briefly below.

### 3.1 World Bank forecast by Prof. Gordon Hughes in 1991

Professor Gordon Hughes performed a forecast in 1991, based on a pooled regression model. He obtained the coefficients for the model from previous analyses of centrally planned economies and analyses of vaguely similar economies in Europe. His forecasts show severe declines in aggregate electricity demand over several time periods as follows:

| | |
|---|---|
| 1989 to 1992 | -29% |
| 1989 to 1995 | -44% |
| 1989 to 2000 | -47% |

Prof. Hughes further uses an energy industry input-output model to look at alternative policy scenarios, where the main policy response is that to electricity price changes. Under this long run interindustry approach, he estimates the following changes to electricity demand:

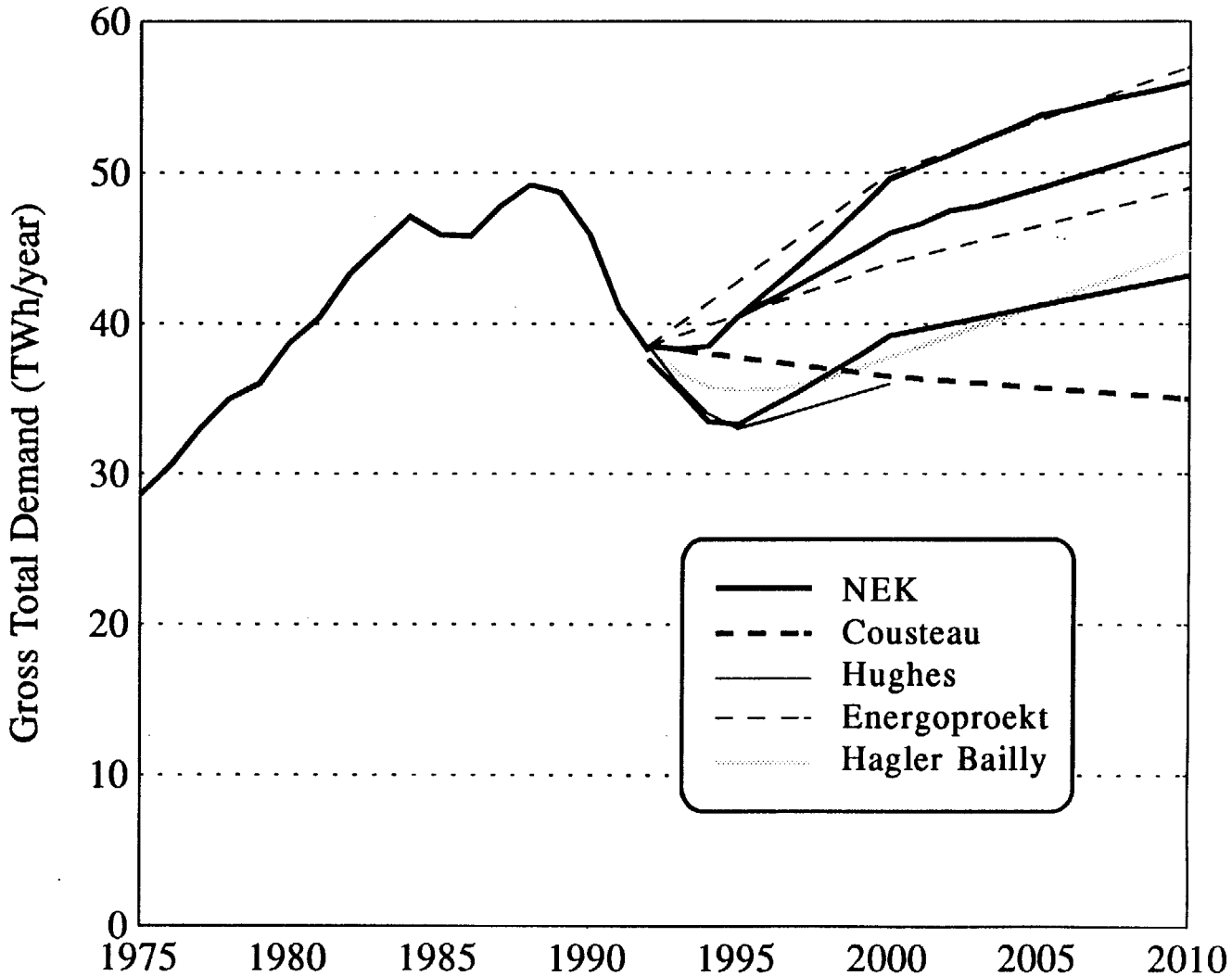
| | 1989 to 1995 | 1989 to 2000 |
|---|---|---|
| Main Projection | -32% | -15% |
| Low Response | -27% | -16% |
| High Response | -32% | -14% |

The response represents changes in electricity demand due to large changes in the price of electricity, deemed necessary to reach appropriate prices for operating a profitable utility.

Exhibit 3-1

# Bulgaria - Total Electricity Demand

Comparison of Previous Forecasts



## 3.2 FORECAST BY NEK, WITH GUIDANCE FROM THE WORLD BANK, IN 1992

For a power system study of the Bulgarian power system at the request of the Group of 7, the World Bank requested a set of demand forecasts from NEK, then worked with NEK in November 1992 to make slight adjustments.

In this forecast, there are three scenarios: maximum, medium, and minimum. The maximum scenarios assumes the most rapid economic growth and the least adjustment by industry to the anticipated higher prices of electricity. The minimum scenario assumes lower economic growth and more adjustment by industry. It also assumes that 450,000 households convert from electricity heating to gas heating after the year 2000. The medium scenario assumes an economic growth between the other two and assumes no major conversions of households to gas heating.

In the medium scenario, electricity demand increases to 52,000 GWh in 2010, and to 56,000 GWh in the maximum scenario. In the minimum scenario, electricity demand increases to 43,200 GWh in 2010. The annual rates of growth in the electricity demand are quite different among these scenarios as can be seen below:

| | 1993 to 2000 | 2000 to 2010 |
|---|---|---|
| Medium | 2.25% | 1.23% |
| Maximum | 3.69% | 1.22% |
| Minimum | 0.60% | 0.98% |

The electricity demand in 2010 for the maximum scenario is approximately 30% larger than that of the minimum scenario. The medium scenario is much closer to the maximum scenario than to the minimum scenario.

## 3.3 ENERGOPROEKT FORECASTS

Energoproekt has furnished several forecasts of electricity demand in the Bulgarian economy. One forecast was done for the United Nations Economic Commission for Europe (ECE) in 1990. This forecast had Bulgarian GDP increasing at about 1.94% per year from 1990 to 2000, with electricity demand increasing from 39,000 GWH to 50,000 GWH, an increase of about 2.5% per year.

In 1991, Energoproekt published a forecast with two scenarios, a high scenario and a low scenario. Both scenarios were based on a GDP growth rate of approximately 2% per year to 2010 (1.94% from 1990 to 2000 and 2.1% from 2000 to 2010). The high forecast shows an increase in electricity demand to 50,000 GWh in 2000 and 57,000 GWh in 2010. This

represents an annual rate of increase of 2.5% from 1990 to 2000, and an increase of 1.3% from 2000 to 2010. The low scenario incorporates some energy efficiency into the forecast and forecasts a growth in electricity demand to the year 2000 of 44,000 GWh (an increase of 1.2% per year) and an electricity demand of 49,000 GWh (an increase of 1.1% per year) in the year 2000.

## 3.4 FORECAST BY EQUIPE COUSTEAU FOR THE EBRD IN 1992

In 1992, Equipe Cousteau prepared a study of the Bulgarian energy future for the European Bank for Reconstruction and Development (EBRD). This study, in collaboration with International Consulting on Energy, was called "Energy in the Danubian Countries, Current Situation, Outlook, and Energy Policy Proposals." The study used the methodology that Energoproekt has used for analyzing the Bulgarian economy, but expanded the methodology to analyze changes in industry structure and improvements in energy efficiency over time. This study assumed that GDP would grow at 2% per year until 2000 and then at 3% per year from 2000 to 2010. Using these assumptions and a decrease in final energy intensity from 0.93 in 1989 to 0.7 in 2000 and 0.5 in 2010, electricity demand decreases from 39,000 GWh in 1989 to 36,500 GWh in 2000 and 35,000 GWh in 2010. This represents a decrease of about 0.67% per year to 2000 and 0.42% per year from 2000 to 2010.

## 3.5 FORECAST BY HAGLER BAILLY IN 1993

A forecast was developed by Hagler Bailly, based on a scenario which reflects a continued difficult economic environment in Bulgaria with low exports, a continued retrenching of industry, high unemployment, high inflation, and high interest rates. Electricity use in industry is also lower in this scenario because of successful conservation programs and because of the reduction in industry output.

In this forecast:

- demand for electricity in the household sector continues to decline, reaching a minimum of 8,400 GWh in 1995, then climbs, reaching 11,000 GWh in 2010.
- in the industrial sector, demand drops slightly, with a minimum of 13,300 GWh in 1994-96, and then begins a gradual climb to 17,000 GWh in 2010.
- total electricity sales reach a minimum of 28,000 GWh in 1994-96 and then rise gradually to its 1988 level of 35,600 GWh around year 2008.

- peak demand reaches a minimum of 6,500 MW in 1994-95, then increases to 9,600 MW by 2010. The 1989 peak of 8,332 MW is reached again in year 2005.

## 3.6 BASE FORECAST CHOSEN FOR COMPARISON AND DSM ANALYSIS

The NEK medium scenario forecast is chosen as the base forecast, for the purposes of projecting the impact of DSM programs.

# 4. CREATING A POLICY FRAMEWORK TO PROMOTE EFFICIENT USE OF ELECTRICITY IN BULGARIA

## 4.1 INTEGRATED RESOURCE PLANNING

Integrated resource planning (IRP) is a concept in which the simultaneous consideration of supply-side and demand-side options is required, in order to minimize the cost of energy services to customers. In the United States, the Energy Policy Act of 1992 requires IRP by all the states, and IRP techniques have been adopted by several countries in Europe.

### 4.1.1 IRP Framework

An overview of a regulatory framework is presented in Exhibit 4-1. The utility regulatory agency adopts IRP, and requires each of the electric utility companies to submit an integrated resource plan. Regulatory approval of tariff increases would require that a least-cost plan for supplying electricity-related energy services be developed, with both the supply-side and the demand-side being adequately considered. DSM programs are developed which are evaluated against supply-side options in an IRP.

The steps used in IRP are shown in Exhibit 4-2. In the IRP approach, first the utility develops a set of objectives for its planning activities in response to its regulatory framework, the incentives available, and external factors and constraints. These external factors often include customer characteristics and preferences. In the development of an IRP, considerable involvement from outside parties is usually encouraged in order to obtain their ideas and address their concerns.

Next, the utility develops the demand forecast and other external constraints[1]. This establishes the need for new resources and forms the basis for the baseline supply-plan and the avoided costs.

Next, the need for new resources is determined by comparing the demand forecast with capacity available from existing resources and facilities currently under construction. Supply-side alternatives are examined to determine the least-cost expansion plan. The avoided cost, both capacity and energy, of the base supply-side scenario is calculated, and used to evaluate other supply-side and demand-side options.

[1] For example, revisions to environmental emissions regulations will require the utility to undertake new investment.

**Exhibit 4-1**
**Regulatory Framework to Encourage Efficient Use of Electricity**

**Regulatory Agency**

- Requires Integrated Resource Plans (IRP) from the electric utilities
- Reviews and approves assumptions made in each IRP, including the load forecast and environmental emissions
- Reviews and approves the investment plan in the IRP, resulting in approval of:
  - Budgets for supply-side investment (generation, transmission, distribution)
  - Budgets for demand-side management (DSM) investment

**Electric Utility Companies**

- Perform the studies, pilot programs and research necessary to prepare an IRP
- Identify the least-cost means of satisfying customers' demand for energy services, considering both demand- and supply-side options
- File an IRP with the appropriate regulatory agency, and defend the plan in hearings
- After gaining approval from the regulatory agency, implement the investment program, including supply-side and demand-side measures



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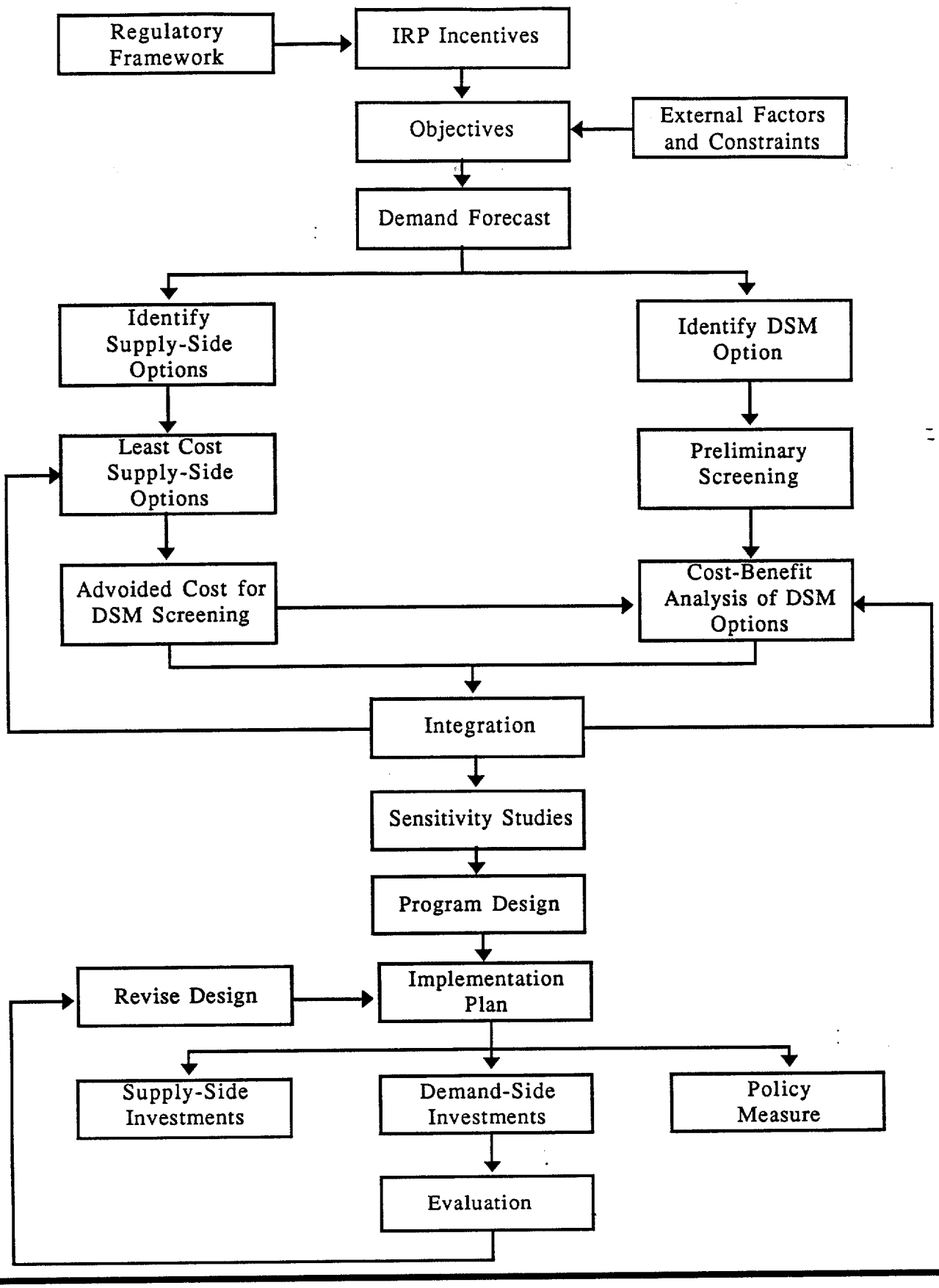
Figure 4-2

## Overview of Integrated Resource Planning



Demand-side options, called demand-side management (DSM), are developed, beginning first with a list of DSM alternative measures. A preliminary screening is performed to eliminate options that do not meet criteria for end-use objectives, availability and applicability. Following this initial screening, a cost-benefit assessment is performed using the avoided costs of the supply-side option.

The next step is integration, which usually requires several iterations between supply-side and demand-side options. A new supply-side plan is developed for this revised level of resources. The avoided cost from this revised plan is then used to re-screen DSM options. Additional cost-effective options from this new screening step are included and the process begins again. Several iterations may be required.

Integration can also involve more detailed analysis of the cost-effectiveness of DSM options. More detailed data may need to be collected and used to perform a more accurate assessment of the cost-effectiveness of the DSM option.

The final result of the integration step is the least-cost scenario of supply-side investment and demand-side options. This scenario and other scenarios are examined in a series of sensitivity studies, which review the cost-effectiveness under a wide range of assumptions.

Once the preferred course of action is identified, an action plan is developed to implement the plan. An action plan includes the tasks to implement the DSM options, including developing data collection tasks and pilot programs, as well as performing full scale DSM programs. The action plan also includes a plan for the development of the supply-side resources included in the preferred scenario.

### 4.1.2 Recommendations for Bulgaria

The legal and regulatory framework for energy and electricity is currently being developed in Bulgaria. There are early drafts of laws governing power plant licensing, building standards, and energy efficiency.

The time is right, therefore, to address the institutional framework and include integrated resource planning requirements in the laws establishing the regulatory framework for the utility.

We recommend that Bulgaria adopt the Integrated Resource Planning approach. This will require the following activities in the short term carried out in parallel:

- require that electricity agencies (Committee of Energy, National Electric Company, and others) assume IRP responsibilities, through enactment of appropriate legislation, regulations, and institutional development;

- develop a least-cost investment plan, considering all supply-side and demand-side options available to Bulgaria, not only from NEK itself but also other sources;

- evaluate electricity tariffs in comparison with long-run marginal costs determined by the least-cost investment plan, and restructure tariffs as required;

- carry out demonstrations under Bulgarian conditions of DSM policies, DSM technologies, DSM implementation strategies, and DSM financing options;

- based on successful demonstrations, develop policy to promote demand-side management (DSM), analyze DSM options in comparison to base case investment plan, and from those measures that are cost-effective, develop a DSM program.

In the remainder of Chapter 4, and in Chapter 5, we provide analysis and recommendations to develop some of these concepts further, particularly those related to demand-side management policy (Chapter 4) and programs (Chapter 5).

## 4.2 IRP OBJECTIVES

IRP objectives should be identified in the mission statement for Bulgaria's electricity sector. We propose the following statement:

> *It is the mission of the electricity sector to provide a reliable supply of electricity-related energy services at the lowest achievable cost, while satisfying all legal and regulatory requirements, especially those related to safety, environmental protection, and electricity pricing.*

Use of the term "energy services" indicates that consumers do not need electric energy (kWh) per se, but rather rotational shaft power (for pumping, ventilation, or material handling), heat, light, and hot water. By focusing on energy services, IRP considers that the customers' demand can be satisfied by other means.

During the winters of 1990/91 and 1991/92, Bulgaria suffered rolling blackouts. Improved reliability is thus an important objective. Modification of the daily load profile (such as

limiting peak demand, or shifting load from peak periods to off-peak) could help achieve improved reliability.

To provide power at least economic cost, in most cases minimizing the use of imported electricity and imported oil and coal used for electricity generation should be an objective.

It is common that government-owned utilities are directed to have further social objectives. An IEA study encourages governments that: "Sectoral cross-subsidies should be removed, and social policies should be kept distinct from energy policies."[2] The need for economic efficiency requires that electricity tariffs be set based on the cost of service for each customer class. If electricity rates are set too low, consumers waste electricity.

Minimizing the environmental impact of electric power generation is another objective. Total emissions can be reduced by installing improved emissions controls, switching to cleaner fuels, by reducing transmission and distribution losses, or by DSM (which reduces the generation required to provide a given level of energy services). Ideally, the economic cost of these impacts should also be considered in the context of the IRP, and consideration of the costs of "environmental externalities" has begun in some states in the U.S.

[2] International Energy Agency, Electricity Supply in the OECD, Paris; 1992, p. 9.

## 4.3 ELECTRICITY TARIFFS

Pricing is the most important step toward promoting the efficient use of electricity, and hence the management of electricity demand. Customers respond to pricing signals, and it is important that the signals reflect the real conditions, such as the cost of service.

### 4.3.1 NEK's Present Tariff Structure

In Bulgaria, as in most countries, electricity tariffs have evolved over the years to a complicated system of prices[3]. The current NEK tariff structure is shown in Exhibit 4-3.

The tariff includes the following features:

- separate tariffs for large customers (commercial and industrial, commonly known in the U.S. as C&I customers), depending on their service voltage;
- different tariffs for C&I customers for winter and summer;
- different tariffs for C&I customers for time of day, by three periods (peak, day and night);
  - for the six months October - March:
    peak hours: 0800-1100 and 1800-2100 (total 6 hours)
    day hours: 0600-0800, 1100-1800 and 2100-2200 (10 hours)
    night hours: 2200-0600 (8 hours)
  - for the six months April - September:
    peak hours: 0800-1200 and 2000-2200 (total 6 hours)
    day hours: 0700-0800, 1200-2000 and 2200-2300 (10 hours)
    night hours: 2300-0700 (8 hours)
- household customers pay much lower prices per kWh than C&I customers;
- separate tariffs for household customers for day and night usage;
- a tariff for purchase of power by NEK from other generators, which is based on the three periods of time of day (peak, day and night).

[3] Latest tariffs available at the time of Hagler Bailly's research were established January 1, 1993, based on Instruction No. 262 of the Council of Ministers on December 28, 1992.

Exhibit 4–3
BULGARIA
EXISTING NEK ELECTRICITY TARIFFS
as of January 1, 1993

| | WINTER TARIFF, Leva/kWh | | | SUMMER TARIFF, Leva/kWh | | |
|---|---|---|---|---|---|---|
| | Peak | Day | Night | Peak | Day | Night |
| **C&I – time–of–day (TOD) metered:** | | | | | | |
| High voltage | 1.395 | 0.757 | 0.374 | 1.217 | 0.655 | 0.322 |
| Medium voltage | 1.447 | 0.783 | 0.386 | 1.255 | 0.679 | 0.333 |
| Low voltage | 1.515 | 0.818 | 0.405 | 1.317 | 0.711 | 0.350 |
| **C&I – single kWh meter (non TOD)** | | | | | | |
| High voltage | 1.125 | 1.125 | 1.125 | 0.978 | 0.978 | 0.978 |
| Medium voltage | 1.161 | 1.161 | 1.161 | 1.009 | 1.009 | 1.009 |
| Low voltage | 1.218 | 1.218 | 1.218 | 1.058 | 1.058 | 1.058 |
| **Households** | **0.440** | **0.440** | **0.233** | **0.440** | **0.440** | **0.233** |
| **Power purchase tariff, sold to NEK from non–utility generators (Leva/kWh)** | | | | | | |
| | **Peak** | **Day** | **Night** | | | |
| | 0.938 | 0.520 | 0.228 | | | |

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### 4.3.2 Preliminary Estimate of the Marginal Cost of Service

#### 4.3.2.1 Introduction to Marginal Cost Pricing

The marginal cost of a good is the incremental cost of producing one additional unit of that good. In a properly functioning competitive market, the price of a good will be approximately equal to the marginal cost of the good. Under these circumstances, the value to consumers of the last unit consumed will be equal to the value of the resources used to produce that unit. In the short-run, competition will drive prices down toward the marginal cost of production from existing capacity. In the long-run, as demand increases, marginal costs must increase to meet the need to expand or rebuild production capacity. The competitors in an ideal competitive marketplace will optimize short-run and long-run considerations, given the level of demand and competitive situation at a particular time. Thus, competitive market forces will result in marginal-cost pricing, and will ensure that society's resources and needs are balanced in the most efficient manner.

In a monopoly situation, there are no market forces tending to optimize prices. In the absence of a competitive market, it is nevertheless true that the economic benefit to society will be maximized by marginal cost pricing. If prices are set below marginal costs, demand will be increased above the economic optimum, and this increased consumption will be subsidized by the supplier. If prices are set above marginal costs, demand will be reduced below the economic optimum, and excessive profits will go to the supplier.

#### 4.3.2.2 Preliminary estimate of marginal costs in Bulgaria

A detailed estimate of the marginal cost of electricity service in Bulgaria is normally carried out in a full tariff study, which is beyond the scope of our work. However, based on limited information from Bulgaria and our experience in conducting tariff studies in other countries, Hagler, Bailly has developed preliminary estimates.

In order to develop costs for analyzing and screening DSM options, we must develop estimates of the long-run marginal cost (LRMC) for capacity (kW) and energy (kWh). For Bulgaria, the installed capacity (approximately 12,000 MW) is apparently sufficient to meet the peak demand (approximately 7,400 MW). However, the poor availability of some plants has not proven sufficient to reliably meet the peak. Furthermore, environmental emissions from existing thermal plants are high. Therefore, investments will be required to rehabilitate and modernize the marginal existing capacity.

The cost of rehabilitating capacity will vary with the individual plant. We estimate costs of $50-100 per kW of generation capacity for basic emission controls, such as improved electrostatic precipitators. This does not include the cost of other upgrading for life extension, availability improvement or sulfur emissions control, which we estimate at a

further $100-500 per kW, or more. These costs approach the cost of a new gas turbine, which, based on recent experience, we estimate as $400 per kW. For the purposes of estimating avoided peak power (kW) cost, we will use the cost of a "rehabilitation project" proxy. This rehabilitation project includes not only generation, but also transmission, and distribution elements.

To estimate avoided energy (kWh) cost, we use the value of electricity generated from a marginal coal-fired plant as a proxy for avoided energy costs.

Exhibit 4-4 shows our preliminary estimate of the medium-term[4] marginal cost of supply, broken out by capacity costs and energy costs, for each voltage level.

[4] Approximately through the year 2000.

## Exhibit 4–4
## Bulgaria
## Estimate of Long–Run Marginal Cost of Electricity Supply

**1. Marginal Capacity Cost:**

Assume: thermal plant rehabilitation and life extension project

| | |
|---|---|
| Discount rate | 10% |
| **Generation:** | |
| Generation reserve margin | 25% |
| T & D losses | 13% |
| kW generation capacity required | 1.41 kW for 1 kW load |
| Life of generator | 20 years |
| Installed cost, US$/kW | $200 |
| Fixed O&M cost, US$/kW/year | $10 |
| Annualized cost, US$/kW/year | $33 per peak kW |
| **Transmission:** | |
| Life of system | 40 years |
| Installed cost, US$/kW | $50 |
| Fixed O&M cost, US$/kW/year | $1 |
| Annualized cost, US$/kW/year | $6 per peak kW |
| **Distribution:** | |
| Life of system | 40 years |
| Installed cost, US$/kW | $100 |
| Fixed O&M cost, US$/kW/year | $5 |
| Annualized cost, US$/kW/year | $15 per peak kW |
| Annualized cost per delivered peak kW | |
| High voltage | $33 per peak kW |
| Medium voltage | $40 per peak kW |
| Low voltage | $55 per peak kW |

**2. Marginal Energy Cost:**

Assume: marginal peak or off–peak generation from thermal steam plants

| | **Peak or Day:** | **Night:** |
|---|---|---|
| Rated Load | 300 MW | 300 MW |
| Heat Rate at rated load | 10,000 kJ/kWh | 11,000 kJ/kWh |
| Heat Rate at part load | 11,000 kJ/kWh | 12,000 kJ/kWh |
| Fuel Used | Imported coal | Domestic lignite |
| Fuel Cost | $2.00 US$/GJ | $1.00 US$/GJ |
| Variable O&M (% of fuel cost) | 10% | 20% |
| Station use of power | 7% | 10% |
| Network losses | | |
| Transmission | 3% | 3% |
| Distribution | 9% | 9% |
| **Total** | **12%** | **12%** |
| Cost per delivered kWh | | |
| High voltage | $0.0260 per kWh | $0.0160 per kWh |
| Medium voltage | 0.0268 per kWh | 0.0165 per kWh |
| Low voltage | 0.0296 per kWh | 0.0182 per kWh |

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In the medium-term, we assume that investments will be required to rehabilitate capacity and reduce environmental emissions, and we have developed estimated costs on that basis. The marginal cost of delivering 1 kW of capacity on-peak, varies from $33 to $55, depending on the voltage level. In addition, the marginal cost of delivering 1 kWh of energy on-peak, varies from $0.026 to $0.030, depending on the voltage level.

Exhibit 4-5 shows assumptions used to convert these estimates of marginal supply costs to marginal customer costs, along the lines of the current NEK tariff structure. The assumptions concern the distribution of customers' energy use across the times of day and seasons of the year. Assumptions are also made concerning the fixed cost of serving a customer, such as the cost of meters, service connection, meter-reading, and billing. Assumptions are also made concerning the distribution of occurrence of forced outages of generation plants.

Exhibit 4-6 provides our preliminary estimate of the marginal cost of service in Bulgaria. The estimate is provided according to customer class, seasons and time of day for both capacity (kW) and energy (kWh). A unified estimate is provided, giving the totals in the form of energy, for direct comparison with the current NEK tariff.

The total energy-based marginal cost varies (depending on the customer class, season of the year, and peak/off-peak) between $0.016 (night, for large high-voltage customer) to $0.069 (winter, household customers).

### 4.3.3 Evaluation of the NEK tariffs

Exhibit 4-7 provides our evaluation of the NEK tariffs, as compared to our preliminary estimates of marginal costs. Our analysis indicates that tariffs for large customers generally are equal to or greater than marginal costs, but that tariffs for household customers are far below marginal costs. During the peak hours in winter, medium voltage C&I customers pay 168% of the marginal cost of service, but household customers pay only 26% of the marginal cost of service.

As far as promoting energy efficiency, the current NEK tariffs include the following general features, which we regard as positive:

- tariffs for C&I customers based service voltage, rather than other considerations (such as whether the customer is industrial, commercial, institutional, or agricultural);
- different tariffs for C&I customers for winter and summer and time of day;
- separate tariffs for household customers for day and night usage;

# Exhibit 4–5
# BULGARIA
# ASSUMPTIONS FOR ESTIMATE OF MARGINAL COST BY TARIFF CLASS

**1. Summary of estimated marginal costs:**

| **Estimated Marginal Capacity Cost:** | **Annualized cost per delivered kW** |
|---|---|
| High voltage | $33 per peak kW/year |
| Medium voltage | $40 per peak kW/year |
| Low voltage | $55 per peak kW/year |

| **Estimated Marginal Energy Cost:** | **Cost per delivered kWh** | |
|---|---|---|
| | **Peak or Day:** | **Night:** |
| High voltage | $0.0260 per kWh | $0.0160 per kWh |
| Medium voltage | 0.0268 per kWh | 0.0165 per kWh |
| Low voltage | 0.0296 per kWh | 0.0182 per kWh |

| **Estimated Marginal Customer Cost** | |
|---|---|
| fixed cost per month for connection equipment metering & billing | $4 per customer |

**2. Assumptions – Customer Characteristics:**

| | Peak Load kW | Avg. Load Factor | Annual Usage MWh | Winter Usage pct | Summer Usage pct |
|---|---|---|---|---|---|
| C&I – HV | 10,000 | 0.7 | 61,320 | 55% | 45% |
| C&I – MV | 1,000 | 0.6 | 5,256 | 55% | 45% |
| C&I – LV | 100 | 0.5 | 438 | 60% | 40% |
| Households | 1 | 0.3 | 2.63 | 65% | 35% |

| | WINTER ENERGY DISTR. | | | SUMMER ENERGY DISTR. | | |
|---|---|---|---|---|---|---|
| | Peak | Day | Night | Peak | Day | Night |
| C&I – HV | 30% | 45% | 25% | 30% | 45% | 25% |
| C&I – MV | 30% | 45% | 25% | 30% | 45% | 25% |
| C&I – LV | 30% | 50% | 20% | 30% | 50% | 20% |
| Households | 30% | 50% | 20% | 30% | 50% | 20% |

| | WINTER ENERGY MWh | | | SUMMER ENERGY MWh | | |
|---|---|---|---|---|---|---|
| | Peak | Day | Night | Peak | Day | Night |
| C&I – HV | 10,118 | 15,177 | 8,432 | 8,278 | 12,417 | 6,899 |
| C&I – MV | 867 | 1,301 | 723 | 710 | 1,064 | 591 |
| C&I – LV | 79 | 131 | 53 | 53 | 88 | 35 |
| Households | 0.51 | 0.85 | 0.34 | 0.28 | 0.46 | 0.18 |

**2. Assumptions – distribution of annual generation forced outages, which result in load–shedding**

| | | | |
|---|---|---|---|
| **Winter** | Peak | 60% | of outages occur in this period |
| | Day | 5% | |
| | Night | 2% | |
| **Summer** | Peak | 30% | |
| | Day | 2% | |
| | Night | 1% | |
| **Total** | | 100% | |

## Exhibit 4–6
## BULGARIA
## ESTIMATE OF MARGINAL COST BY TARIFF CLASS

**1. Marginal costs for capacity ($/kW) including capacity and customer costs**

| | WINTER COST, $/kW/MONTH | | | SUMMER COST, $/kW/MONTH | | |
|---|---|---|---|---|---|---|
| | Peak | Day | Night | Peak | Day | Night |
| C&I – HV | $2.79 | $0.23 | $0.09 | $1.40 | $0.09 | $0.05 |
| C&I – MV | 3.33 | 0.28 | 0.11 | 1.66 | 0.11 | 0.06 |
| C&I – LV | 4.63 | 0.39 | 0.15 | 2.32 | 0.15 | 0.08 |
| Households | 8.59 | 0.72 | 0.29 | 4.30 | 0.29 | 0.14 |

**2. Marginal costs for energy ($/kWh) including energy only**

| | WINTER COST, $/kWh | | | SUMMER COST, $/kWh | | |
|---|---|---|---|---|---|---|
| | Peak | Day | Night | Peak | Day | Night |
| C&I – HV | $0.026 | $0.026 | $0.016 | $0.026 | $0.026 | $0.016 |
| C&I – MV | 0.027 | 0.027 | 0.016 | $0.027 | $0.027 | $0.016 |
| C&I – LV | 0.030 | 0.030 | 0.018 | $0.030 | $0.030 | $0.018 |
| Households | 0.030 | 0.030 | 0.018 | $0.030 | $0.030 | $0.018 |

**3. Total marginal costs on per kWh basis including energy, capacity, and cusotmer costs**

| | WINTER COST, $/kWh | | | SUMMER COST, $/kWh | | |
|---|---|---|---|---|---|---|
| | Peak | Day | Night | Peak | Day | Night |
| C&I – HV | $0.031 | $0.026 | $0.016 | $0.029 | $0.026 | $0.016 |
| C&I – MV | 0.034 | 0.027 | 0.017 | 0.031 | 0.027 | 0.017 |
| C&I – LV | 0.042 | 0.031 | 0.019 | 0.036 | 0.030 | 0.018 |
| Households | 0.069 | 0.033 | 0.019 | 0.049 | 0.031 | 0.019 |

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## Exhibit 4–7
## BULGARIA
## EVALUATION OF TARIFF

**1. Tariff existing as of January 1, 1993**

| | WINTER TARIFF, Leva/kWh | | | SUMMER TARIFF, Leva/kWh | | |
|---|---|---|---|---|---|---|
| | Peak | Day | Night | Peak | Day | Night |
| C&I – HV | 1.395 | 0.757 | 0.374 | 1.217 | 0.655 | 0.322 |
| C&I – MV | 1.447 | 0.783 | 0.386 | 1.255 | 0.679 | 0.333 |
| C&I – LV | 1.515 | 0.818 | 0.405 | 1.317 | 0.711 | 0.350 |
| Households | 0.440 | 0.440 | 0.233 | 0.440 | 0.440 | 0.233 |

**based on exchange rate: 25.00 Leva = $1.00**

| | WINTER TARIFF, $/kWh | | | SUMMER TARIFF, $/kWh | | |
|---|---|---|---|---|---|---|
| | Peak | Day | Night | Peak | Day | Night |
| C&I – HV | $0.056 | $0.030 | $0.015 | $0.049 | $0.026 | $0.013 |
| C&I – MV | 0.058 | 0.031 | 0.015 | 0.050 | 0.027 | 0.013 |
| C&I – LV | 0.061 | 0.033 | 0.016 | 0.053 | 0.028 | 0.014 |
| Households | 0.018 | 0.018 | 0.009 | 0.018 | 0.018 | 0.009 |

**2. Tariff existing as of January 1, 1993 as percentage of marginal costs**

| | WINTER TARIFF, pct of COST | | | SUMMER TARIFF, pct of COST | | |
|---|---|---|---|---|---|---|
| | Peak | Day | Night | Peak | Day | Night |
| C&I – HV | 177% | 114% | 92% | 169% | 100% | 80% |
| C&I – MV | 168% | 114% | 92% | 164% | 100% | 80% |
| C&I – LV | 143% | 107% | 87% | 147% | 95% | 76% |
| Households | 26% | 54% | 48% | 36% | 57% | 49% |

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- a time-of-day tariff for purchase of power by NEK from other generators.

The current tariff includes several features which we regard as negative:

- subsidies for household customers;
- no specific charges in the C&I tariff for capacity (kW); all charges are lumped into an energy charge (kWh);
- no incentives are offered for power factor (cos phi) improvement;
- the power purchase tariff also includes no specific payments for capacity (kW), only for energy (kWh).

### 4.3.4 Recommendations for Tariff Reform

The preliminary analysis indicates serious deficiencies in the tariff structure. The tariff structure gives pricing signals to customer which will continue to affect their demand for energy services, and hence NEK's operations and investment planning. Hagler, Bailly recommends that the structure be modified to a structure which reflects the long-run marginal cost of service, based on the results of a detailed tariff study.

#### 4.3.4.1 Tariff Study

The essence of an economic tariff setting methodology is based upon the recognition that an effective and acceptable set of tariffs can only be arrived at by a compromise between the following set of multiple objectives, some of which may be conflicting: to encourage economic efficiency in resource utilization, to ensure financial viability of the power authority including its ability to finance future resource mobilization, and to recognize the social welfare consequences of a tariff as well as other sociopolitical priorities of equity, fairness, sectoral and regional development.

The tariff study includes several steps:

1. engineering analysis of the cost of service, including seasonal, time-of-day, and reliability considerations, as well as review of the planned least-cost investment program.
2. development of a sales forecast for the electric utility.

3. economic analysis, to estimate of the long-run marginal cost (LRMC) of supplying electricity.

4. financial analysis, to estimate the average revenue requirement target of the electric utility, in $/kWh, to ensure the financial viability.

5. analysis of customer billing records to develop the profile of sales to customers under each tariff class.

6. development of strict LRMC tariff, based on economic cost of service to each customer class.

7. development of revenue-neutral LRMC tariff, based on allocation of the financial revenue requirement across customer classes

8. development of practical tariff, adjusting the revenue-neutral LRMC to account for social, political, developmental and other considerations.

9. development of adjustment provisions, to handle external influences such as fuel price changes or inflation

10. development tariffs for special situations, such as purchase of power from other sources, or for interruptible supply

An important objective of the tariff study in Bulgaria must be to transfer the know-how of tariff design to NEK staff. The tariff study sets the strategy for continuous involvement of key individuals in the important task of price-setting. A select group of key members of the NEK's management and technical staff must first be identified in the functional areas of relevance to this project. These areas include system planning (generation, transmission and distribution), load forecasting and load research, finance, metering, and billing.

#### 4.3.4.2 Implementation of Tariff Restructuring

Ultimately, the success of the tariff study project will be judged not by the report, but by the changes made to the tariffs. After completion of the report, in order to get the tariff implemented, there are several other steps that will be required in Bulgaria:

1. Possible revisions to the analysis based on the presentations to COE and NEK

2. Prepare a submission to seek regulatory authority (or government) approval.

3. Defend the tariff to the authority.

4. Possibly revise the tariff and financial analysis based on the decision of the authority.

5. Prepare the Gazette announcement.

6. Prepare customer information explaining the new tariff and its rationale.

7. Defend the tariff in meetings with customer, and in the public media.

8. Change metering systems, where necessary.

9. Change billing systems.

10. Test the new billing system.

11. After some months, analyze the effect of any structural changes made on revenue collection.

12. Revise tariff structure if performance is not as expected.

## 4.4 PRIVATE POWER, AND DEVELOPMENT OF INDEPENDENT POWER PRODUCTION (IPP)

As part of Integrated Resource Planning, consideration must be made of all sources of supply. Independent power generation usually relates to supply of electricity to the grid by facilities not under the ownership or direct control of the electric utility (such as NEK). In Bulgaria, such projects would be developed by the private sector, and could be a first step toward privatization of electricity services.

The potential benefit of independent power to Bulgaria is greater economic efficiency, obtained through competition in power generation, access to financing and additional capital, optimal use of energy resources through combined heat and power, and transfer of new technology.

As part of this A.I.D.-funded project, a separate report was prepared by Hagler Bailly on this subject, entitled "Independent Power Generation in Bulgaria: Assessment of Potential, Impediments and Options", August 1993.

## 4.5 DEMAND-SIDE MANAGEMENT (DSM)

Demand-side management (DSM) refers to a wide variety of activities which are carried out to improve the efficiency of electricity usage by customers, with cooperation from the electric utility company. DSM thus represents a partnership between the electric company and its customer. There can be other partners in DSM programs, such as private sector energy services companies, financial institutions, and energy engineering firms.

DSM includes programs to encourage conservation, energy efficiency, and load management actions. DSM can also include actions to increase power sales in the off-peak periods. DSM is chosen over a supply-side option when DSM is clearly shown to offer a lower cost alternative to the economy of Bulgaria.

However, whereas the calculation may show DSM to be the least cost option for the country as a whole, the calculation may be different when investigated from the utility's perspective. Thus, in some countries, electric utilities have been reluctant to implement DSM, because financial issues have not been adequately resolved. Implementing DSM has not been in the utilities' interest in those countries where the local regulatory process ties revenues only to energy (kWh) sales. In these cases, savings in energy from demand-side programs reduce the sales of the utility (revenues are lost). In some countries, management (and other employee) compensation or bonuses may even be tied to revenue or kWh sales.

For DSM to succeed, it is necessary that the Bulgarian electric utilities be given the proper financial incentive, so that their decisions are able to mirror what is best for the country.

There is a distinction between DSM "measures" and DSM "programs". Measures refer to a discrete DSM action or technology. A DSM program includes one or more DSM measures in a package that can be marketed and provided to the customer. An example of a DSM measure is replacing standard-efficiency electric motors with high-efficiency motors. An example of a DSM program would be a system of incentives offered by the utility to help implement the measure, such as a rebate of 50% of the purchase price of motors which qualify as high-efficiency motors. The program would include a system for utility or contract personnel to go to the customer's plant, examine the customer's motors, and determine whether it is appropriate to replace the motors. Alternatively, a bidding program could be used, in which case the customers make proposals to the utility for partial funding of measures which meet a general criteria.

The DSM analysis is presented in two parts. In this section, we evaluate the need for DSM incentives in Bulgaria. In the next chapter, we assess the potential for DSM in Bulgaria.

### 4.5.1 Sources of Data

The primary sources of data used in the DSM analysis were:

- DBC's Survey of the 106 largest electricity customers in Bulgaria, as described in Chapter 2. This survey included items concerning production plans, electricity use, and previous experience with energy conservation.

- Energy Audits of 8 enterprises in Bulgaria, carried out in 1991 by International Resources Group (IRG), under the U.S. Agency for International Development (AID) Emergency Energy Project[5].

- Interviews of energy professionals in Bulgaria, carried out in 1992 and January 1993 by Hagler, Bailly. These professionals represented the Committee of Energy, NEK, Ministry of Industry, Technical University of Sofia, EC energy center, engineers providing energy efficiency services (such as energy audits and energy-saving equipment), and industrial plant managers.

- Experience gained by the Hagler, Bailly project staff through DSM program design and energy efficiency in the U.S. and other countries over the past 20 years was applied where inadequate data were available for Bulgaria.

This study goes as far as possible in developing a basic DSM assessment with the existing information. In many instances, data on electricity end-use in Bulgaria were not available. The same situation occurred in the early experience of U.S. utilities. When DSM programs were first considered in the United States, data were not available to perform cost-benefit studies. As they gained experience with implementing DSM programs, utilities developed the procedures and data needed.

### 4.5.2 The Need for Incentives for DSM

In many countries, electric utilities have been reluctant to implement DSM, and Bulgaria is no exception. There are several factors involved, including:

- Management incentives
- Traditional familiarity with, and focus on, supply-side options
- Profit incentives due to regulatory structure

[5] The results of these audits were augmented by the results of 52 other energy audits carried out in other Eastern European countries under the AID Emergency Energy Project.

Management (and other employee) compensation or bonuses may be tied to revenue, sales or profit growth. In some Eastern European countries, a bonus is paid to employees based on kWh sales. Management often operates under the concept that "bigger is better", a concept at odds with implementing DSM programs that are often associated with decreasing sales, revenues, and profits.

Utilities have traditionally focused on supply-side options. Of course, utilities and their personnel take pride in their power plants and other capital assets. DSM measures are something new and different to utility personnel.

The largest area of concern, however, is that implementing DSM has often not been in the utilities' interest because of the way the regulation has been implemented. In essence, the regulatory process has resulted in a situation where growth in sales results in additional profit for a utility, or savings in energy from demand-side programs reduces the profit of the utility.

Another feature of the regulatory approach that could be a factor working against DSM is the electricity tariff-setting procedure, based on a fixed historical or expected future level of expenses and sales. Typically, an expected level of expenses is divided by the expected level of sales to determine the rates to be charged to customers. The level of expenses and sales can be either a historical level (historical test-year) or projected level (future test-year).

The actual revenue and profit earned by the utility will vary from that determined in the rate setting procedure because both the level of expenses and sales will likely be different from that used in the rate setting proceeding. Between rate cases, each additional kWh of sales will result in additional profit for the utility. Utilities in the normal mode, growth and marginal revenue exceeding marginal cost, will receive additional profit from growth. If a utility implements DSM measures to reduce sales, the reduction in sales will cut into profit created by growth.

This reduction in revenue because of DSM programs is often referred to as the "lost revenue" problem. Because DSM programs introduce technologies that over their lifetimes more than pay back the investment in energy savings, the amount of revenue lost by the utility will be much more than the direct cost of DSM programs.

### 4.5.3 Alternative Incentive Approaches to DSM

A number of approaches have been proposed, and several adopted, to provide incentives for utilities to invest in DSM. A few of the more important proposals are briefly discussed below.

- **Adjusting rates to cover revenue losses (decoupling)** - The approach adjusts the utility's actual recovery of revenues to match the amount approved by the regulatory agency so that there is no additional profit from growth or loss of profit from DSM measures. Decoupling addresses both the incentive for growth and the lost revenue problem.

- **Adjustment clause to recover expenditures for DSM** - Significant increases in expenditures to a level not anticipated in the utility rate case, such as the implementation of a large-scale DSM program, can result in expenses not recovered by the utility. An adjustment clause that charges DSM expenditures to customers ensures a utility recovers its program costs in the same year the expenditures are incurred.

- **Rate-basing of DSM investments** - Hardware costs, utility labor costs, and the cost of certain services for DSM can be placed in rate base, for recovery in future years. Rates would be increased to amortize the amount of the expenditures and to allow the utility to earn a return on the investment. Often, an accelerated depreciation or amortization schedule is included as a further incentive. Several utilities use some form of rate basing.

- **Adjusting the rate of return on DSM investments** - The return on DSM investments would receive a premium level of allowed return so that DSM expenditures would be perceived by the utility as being more profitable than supply-side investments. For example, utilities in the states of Washington and Montana are allowed to earn an additional 2% return on DSM expenditures.

- **Performance criteria for rate of return incentive** - The utilities rate of return is adjusted if the utility achieves a certain level of DSM — a specified level of peak demand (MW) or energy (MWh) savings. For example, the Public Service Commission of Wisconsin offered Wisconsin Electric Power Company an additional 1% rate of return for conservation expenditures for each 125 MW reduction in peak demand.

- **Incentives proportional to savings** - Utilities are offered a fixed payment per unit of peak demand or energy savings. The payment would be set based on a calculation designed to share the savings between customers and the utility.

### 4.5.4 Recommended DSM Incentives for Bulgaria

For DSM to succeed, it will be necessary that the Bulgarian electric utilities be given a profit incentive, which would be totally consistent with an IRP regulatory framework. A technical

assistance program provided by foreign experts would enable Bulgaria to benefit from the many years of DSM experience which has been obtained in the U.S. and other countries.

The recommended first incentives are summarized below.

- Allow DSM capital investments by the utility to earn a rate of return which is high enough to encourage the utility to make the investment;

  Appropriate DSM investments should be included in the capital rate base. The types of investments to be included will mainly be for capital investments for hardware projects. The amortization period should be 3-10 years, depending on the type of investment.

  As a further incentive, to compensate for years of inattention to the demand-side, the rate of return for DSM expenditures should be set higher than that allowed for conventional supply-side expenditures. An appropriate level of incentive would be 2-5% higher.

- Allow other (non-capital) DSM expenses incurred by the utility to be recovered through tariffs in the same year they are incurred.

  The utility should be allowed to recover the full cost of incidental (non-investment) expenditures for DSM. Expenses such as utility labor costs, promotion materials, services by outside agencies would be allowed to be recovered. These expenses should be recovered in the year they are incurred, as part of the budget process.

- Provide utility employee incentives based on services and efficiency, rather than energy sales.

  Utility personnel should be given salary bonuses or incentives based on energy services and efficiency improvements. Any performance incentives still based on kWh generated or kWh sold should be replaced with efficiency-related incentives.

# 5. DEVELOPMENT OF AN ILLUSTRATIVE DEMAND-SIDE MANAGEMENT PROGRAM FOR BULGARIA

## 5.1 DEVELOPMENT OF CANDIDATE ENERGY EFFICIENCY MEASURES

### 5.1.1 Analysis of Existing Load Shape

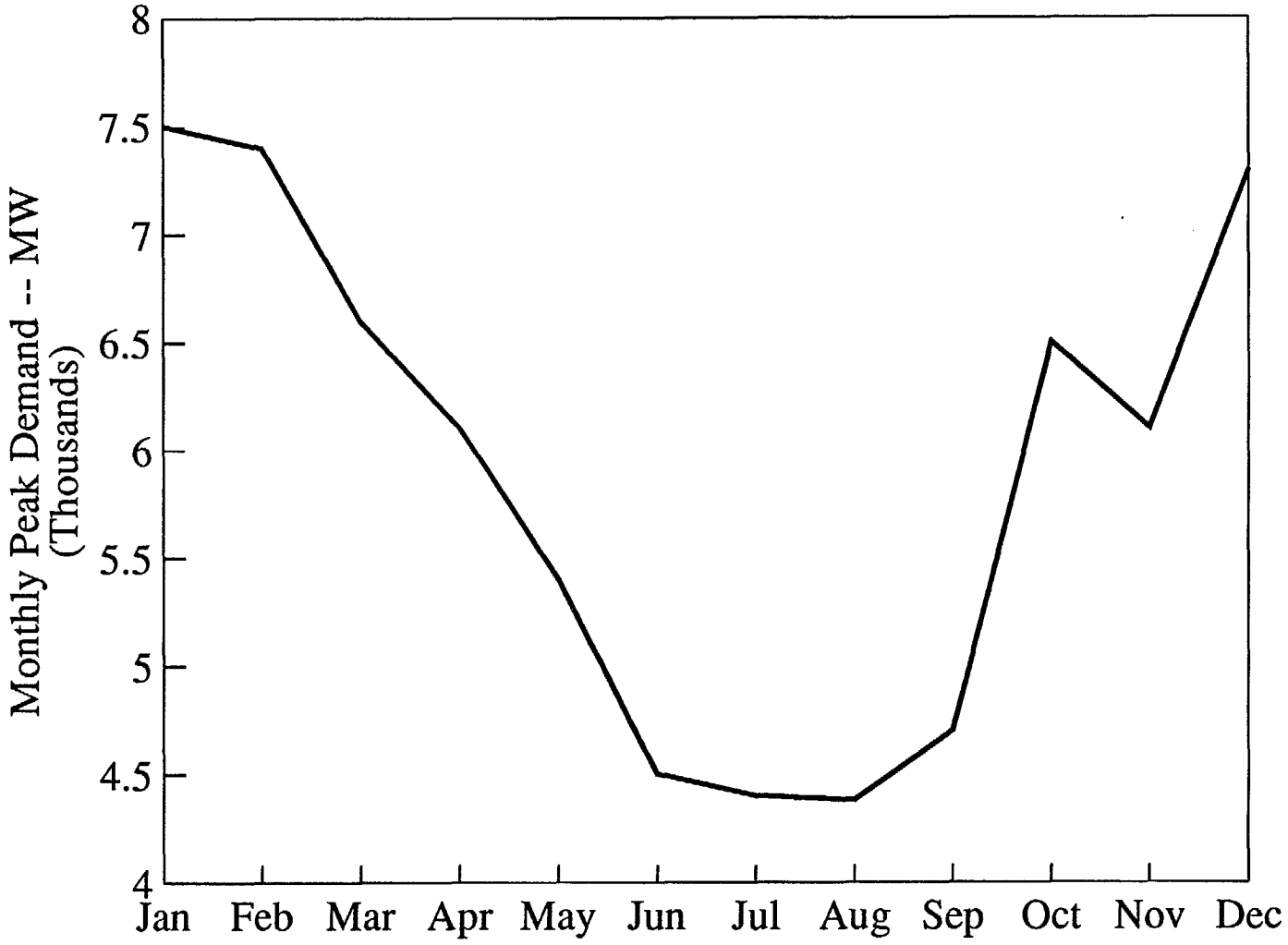
The monthly variation in peak demand (MW) for the NEK system 1991 is shown in Exhibit 5-1. Peak demand in 1991 was 7,489 MW. The peak occurs in winter; demand in the summer is approximately 3,000 MW lower.

Exhibit 5-2 shows the annual load duration curve for 1982 and 1991. Over this period, the peak demand grew by about 5%, however off-peak usage declined. This indicates that the character of usage (and load factor) is changing. It is especially important to note that a substantial amount of winter heating in residences and other buildings is done by electric resistive heating. The National Electric Company estimates that a substantial part of the difference in peak demand between winter and summer (1,800 MW) is due to heating.

Exhibits 5-3, 5-4 and 5-5 illustrate the daily load shape (MW vs. hour of the day) for January and July. Daily load has two peaks, one in the morning and one in the evening. The evening peak is usually the highest, but in some months (e.g., February 1991) the morning peak was higher. The evening peak is 19 to 20 hours (7:00 to 8:00 pm). Winter load is relatively high for a long period, from 7 hours until 24 hours. In fact, the daily load factor (average load divided by peak load) on the average January weekday is over 0.9, which is exceptionally high. Summer load peaks around midday and stays relatively high until about 23 hours.

Exhibit 5-1

# Peak Demand by Month
# Bulgaria 1991




1991

Exhibit 5-2

# Load Duration Curve
# Bulgaria -- 1991 and 1982

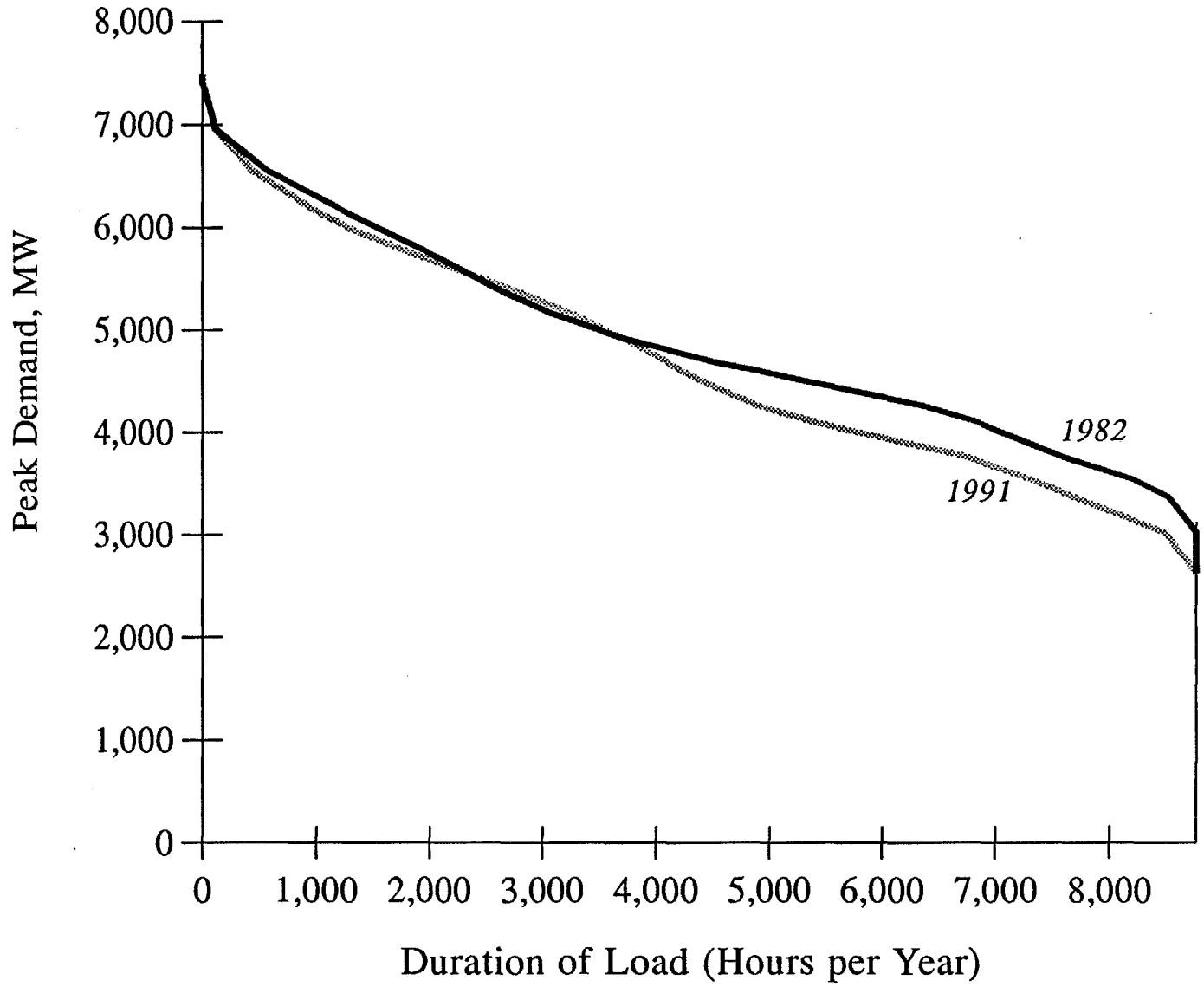


Exhibit 5-3

# Daily Load Profile - Bulgaria

## Average Day in January & July

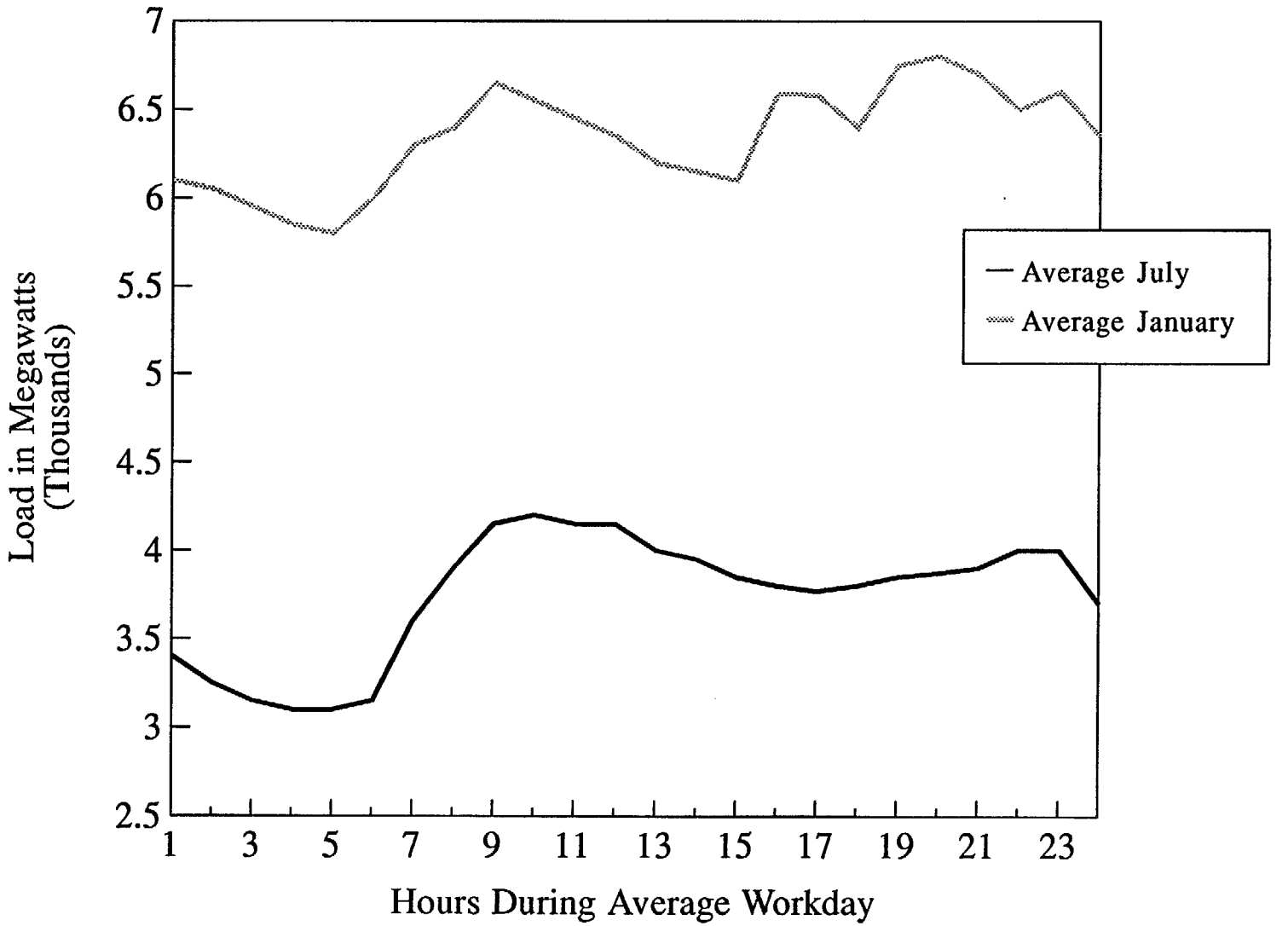


Exhibit 5-4

# Daily Load Profile - Bulgaria

## Average Day in January

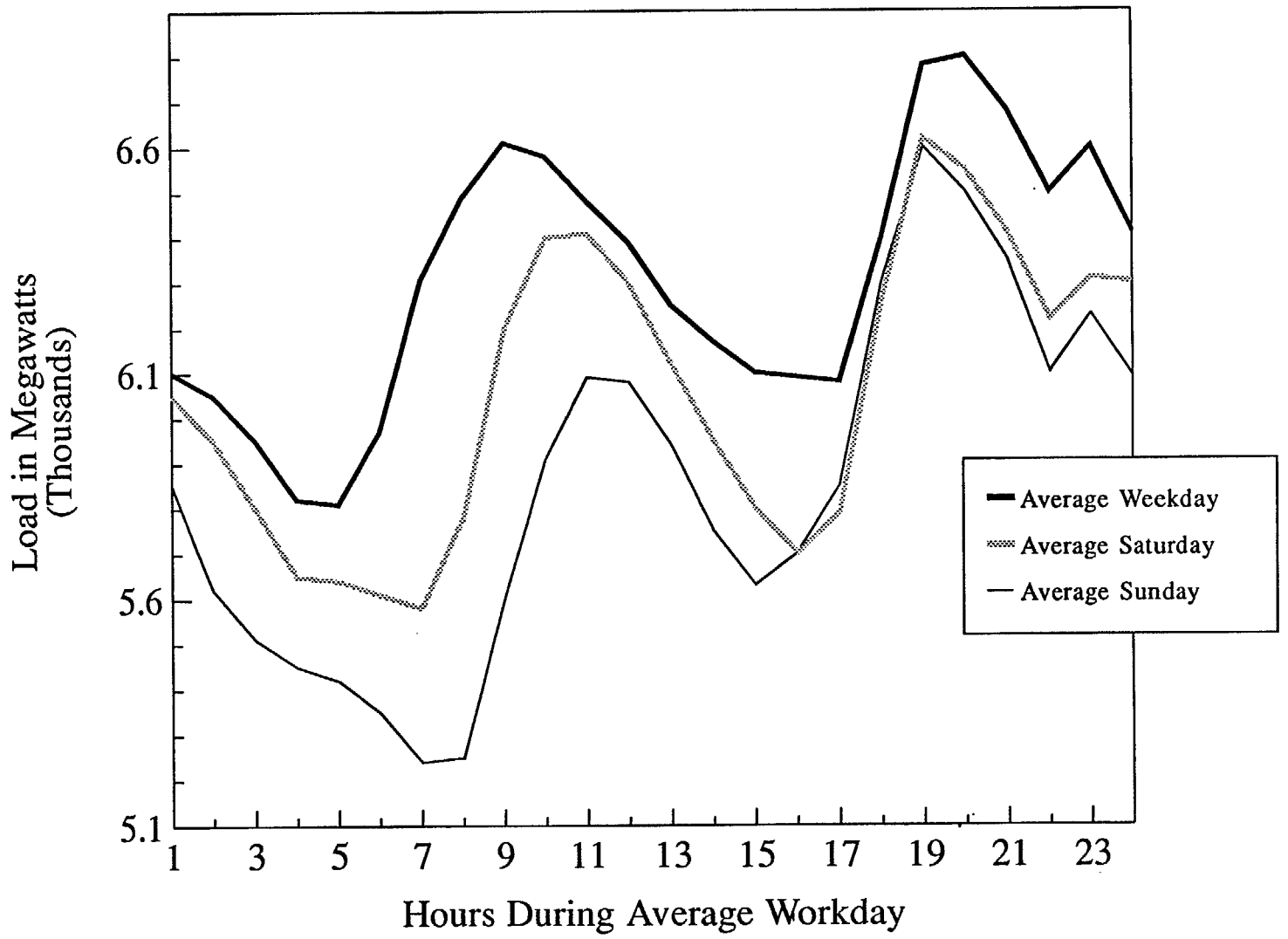
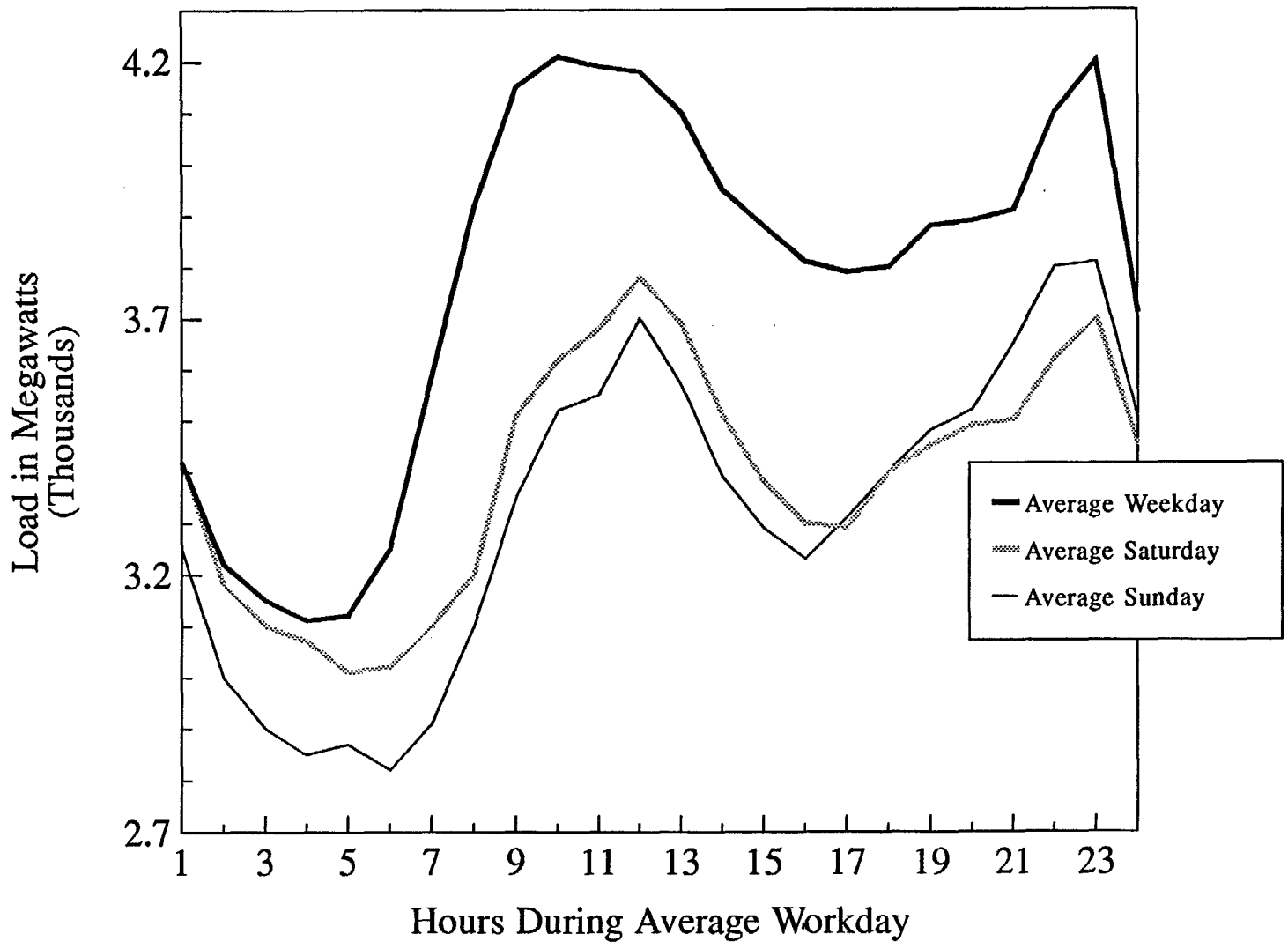


Exhibit 5-5

# Daily Load Profile - Bulgaria

## Average Day in July



### 5.1.2 DSM Program Design Criteria

DSM programs are usually designed to achieve specific load-shape modifications, as required by the utility system. Examples of programs are:

- Peak Clipping (reducing peak MW demand)
- Valley Filling (adding kWh sales in off-peak periods)
- Load Shifting (moving kWh from peak to off-peak periods)
- Strategic Conservation (reducing kWh sales in high-cost periods)
- Strategic Load Growth (increasing kWh sales in low-cost periods)
- Flexible Load Shape (interruptible customers)

Based on analysis of the NEK load shapes, we regard the following as a reasonable set of criteria for DSM program design in Bulgaria:

- End-use - addressing the industrial and buildings sectors
- Load shape - addressing the need for peak demand reduction in winter
- Relative costs - recognizing the need to favor low-cost measures
- Equipment and services availability in Bulgaria - recognizing the current economic crisis and the transition to private enterprise and a market economy

Not all forms of DSM are appropriate targets for Bulgaria. In our judgment, the following types of DSM programs should be most encouraging:

- Peak clipping in winter,
- Conservation in winter and summer,
- Flexible load shape in winter

### 5.1.3 DSM Measure Pre-screening

Based on the characteristics of the system, those DSM measures that appear applicable to Bulgaria were selected from a list of candidate measures.

DSM measures can often be divided into new, replacement, and retrofit measures. Because of high capital costs, few decision-makers will elect to install a new, more efficient piece of equipment unless the old unit is near the end of its economic life or has actually failed and must be replaced. For new- and replacement-related (as opposed to retrofit-related) measures, the economics of the measure should be assessed as the additional cost of the high-efficiency measure compared to the standard efficiency equipment. Replacement is often considered as a function of the life of the equipment to indicate the need for replacement at the end of the life of equipment. Retrofit or add-on measures do not require the replacement of existing capital-intensive equipment.

A core set of measures used in screening was drawn from a library of more than 100 typical DSM measures. The results of the screening are shown in Exhibit 5-6 (for buildings), and Exhibit 5-7 (industrial).

**Exhibit 5–6**
**BUILDINGS SECTORS (RESIDENTIAL, COMMERCIAL, INSTITUTIONAL) DSM MEASURE SCREENING**
**BULGARIA**

| DSM Family | Code | Typical US–type DSM Measure | End Use Impacted | Load Shape Impact: Meets End Use Objective | Load Shape Impact: Peak Impact (W/S/ Both) | Load Shape Impact: Significant Energy Savings | Load Shape Impact: Meets Load Shape Objective | DSM Form | Meets DSM Form Objective | Relative Costs | Meets Cost Objective | Bulgaria Equipment Available? | Meets Availability Objective | Recommended: For Data Collection | Recommended: For Load Research | Recommended: For Pilot Programs |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Building Heating | 101 | Increase Ceiling Insulation | Space Heat | Yes | Winter | Yes | Yes | Str. Consv. | Yes | Low | Yes | Yes | Yes | Yes | Yes | Audit |
| | 102 | Increase Wall Insulation | Space Heat | Yes | Winter | Yes | Yes | Str. Consv. | Yes | Low | Yes | Yes | Yes | Yes | Yes | Audit |
| | 103 | Insulate Doors | Space Heat | Yes | Winter | Yes | Yes | Str. Consv. | Yes | Low | Yes | Yes | Yes | Yes | Yes | Audit |
| | 104 | Install Storm Windows | Space Heat | Yes | Winter | Yes | Yes | Str. Consv. | Yes | Low | Yes | Yes | Yes | Yes | Yes | Audit |
| | 105 | Add Plastic to Windows | Space Heat | Yes | Winter | Yes | Yes | Str. Consv. | Yes | Low | Yes | Yes | Yes | Yes | Yes | Audit |
| | 106 | Caulking/Weatherstripping | Space Heat | Yes | Winter | Yes | Yes | Str. Consv. | Yes | Low | Yes | Yes | Yes | Yes | Yes | Audit |
| | 107 | Install air source heat pump | Space Heat | Yes | Winter | Yes | Yes | Str. Consv. | Yes | Low | Yes | Uncertain | Data Req. | Yes | No | No |
| | 108 | Add Thermostat/Regulator | Space Heat | Yes | Winter | Yes | Yes | Str. Consv. | Yes | Low | Yes | .Yes | Yes | Yes | Yes | Audit |
| | 109 | Thermal energy storage | Space Heat | Yes | Winter | Yes | Yes | Valley Fill | No | Med/Hi | No | Uncertain | Data Req. | No | No | No |
| | 110 | Fuel Conversion: Electric to Gas | Space Heat | Yes | Winter | Yes | Yes | Str. Consv. | Yes | High | No | Yes | Yes | Yes | Yes | Fuel Switch |
| | 111 | Direct load control – heat | Space Heat | Yes | Winter | No | Yes | Peak Clip | Yes | Low | Yes | No | Data Req. | Yes | Yes | Yes |
| Elect. Water Heating | 201 | Water Heater Wraps, Pipe Insulation | Water Heat | Yes | Both | Yes | Yes | Str. Consv. | Yes | Low | Yes | Yes | Yes | Yes | Yes | Audit |
| | 202 | Flow restrictors | Water Heat | Yes | Both | Yes | Yes | Str. Consv. | Yes | Low | Yes | Uncertain | Data Req. | Yes | Yes | More Data |
| | 203 | Add Timer to Operate WH Off–Peak | Water Heat | Yes | Both | Yes | Yes | Str. Consv. | Yes | High | No | Uncertain | Data Req. | Yes | No | No |
| | 204 | WH Thermostat | Water Heat | Yes | Both | Yes | Yes | Str. Consv. | Yes | Medium | Yes | Uncertain | Data Req. | Yes | No | No |
| | 205 | Water Heater (Direct Load Control) | Water Heat | Yes | Both | Yes | Yes | Peak Clip | Yes | Medium | Yes | Uncertain | Data Req. | Yes | Yes | Curtail. Load |
| | 206 | Storage Water Heater | Water Heat | Yes | Both | Yes | Yes | Peak Clip | Yes | Medium | Yes | Uncertain | Data Req. | Yes | No | No |
| | 207 | Electric to Gas Water Heater | Water Heat | Yes | Both | Yes | Yes | Str. Consv. | Yes | Medium | Yes | Yes | Yes | Yes | Yes | Fuel Switch |
| Cooking | 301 | New stove – spiral heating elements | Cooking | Yes | Both | Yes | Yes | Str. Consv. | Yes | Medium | Yes | Uncertain | Data Req. | Yes | Yes | Ap. Standards |
| | 302 | Electric Cooking to Gas Cooking | Cooking | Yes | Both | Yes | Yes | Str. Consv. | Yes | Medium | Yes | Yes | Yes | Yes | Yes | Audit |
| Refrig. | 401 | High Efficiency Refrigerator–Import | Refrigeratio | Yes | Both | Yes | Yes | Str. Consv. | Yes | High | No | Yes | Yes | Yes | No | No |
| | 402 | High Efficiency Refrigerator–Domestic | Refrigeratio | Yes | Both | Yes | Yes | Str. Consv. | Yes | Medium | Yes | Uncertain | Data Req. | Yes | Yes | Ap. Standards |
| Lighting | 501 | Res. Incandescent to Compact Fluor. | Lighting | Yes | Winter | Yes | Yes | Str. Consv. | Yes | Low | Yes | Uncertain | Data Req. | Yes | Yes | Aud/Light. |
| | 502 | Res. Energy Eff. Incandescent | Lighting | Yes | Winter | Yes | Yes | Str. Consv. | Yes | Low | Yes | Uncertain | Data Req. | Yes | Yes | Aud/Light. |
| | 503 | Res. Incandescent to Std. Fluor. Fixture | Lighting | Yes | Winter | Yes | Yes | Str. Consv. | Yes | Low | Yes | Uncertain | Data Req. | Yes | Yes | Lighting |
| | 504 | Commercial Incand. to Compact Fluor. | Lighting | Yes | Winter | Yes | Yes | Str. Consv. | Yes | Low | Yes | Uncertain | Data Req. | Yes | Yes | Lighting |
| | 505 | Fixture replace w/ EELamps & EEBal. | Lighting | Yes | Winter | Yes | Yes | Str. Consv. | Yes | Low | Yes | Uncertain | Data Req. | Yes | Yes | Lighting |
| | 506 | Fixture replace w/ Delamping & Refl. | Lighting | Yes | Winter | Yes | Yes | Str. Consv. | Yes | Low | Yes | Uncertain | Data Req. | Yes | Yes | Lighting |
| | 507 | Day Lighting Control | Lighting | Yes | Summer | Yes | No | Str. Consv. | Yes | Medium | Yes | Uncertain | Data Req. | No | No | No |
| | 508 | High Efficiency Lamps | Lighting | Yes | Winter | Yes | Yes | Str. Consv. | Yes | Low | Yes | Uncertain | Data Req. | Yes | Yes | Lighting |
| | 509 | EMS Lighting | Lighting | Yes | Winter | Yes | Yes | Str. Consv. | Yes | Low | Yes | Uncertain | Data Req. | Yes | Yes | Lighting |
| | 510 | Occupancy Sensors | Lighting | Yes | Winter | Yes | Yes | Str. Consv. | Yes | Low | Yes | Uncertain | Data Req. | Yes | Yes | Lighting |
| | 511 | Mercury vapor to HPS | Lighting | Yes | Winter | Yes | Yes | Str. Consv. | Yes | Low | Yes | Uncertain | Data Req. | Yes | Yes | Lighting |
| | 512 | Incandescent to HPS | Lighting | Yes | Winter | Yes | Yes | Str. Consv. | Yes | Low | Yes | Uncertain | Data Req. | Yes | Yes | Lighting |
| | 513 | Incandescent to Metal Halide | Lighting | Yes | Winter | Yes | Yes | Str. Consv. | Yes | Low | Yes | Uncertain | Data Req. | Yes | Yes | Lighting |
| | 514 | Incandescent to Fluorescent | Lighting | Yes | Winter | Yes | Yes | Str. Consv. | Yes | Low | Yes | Uncertain | Data Req. | Yes | Yes | Lighting |

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# Exhibit 5–7
# INDUSTRIAL SECTOR DSM MEASURE SCREENING
# BULGARIA

| DSM Family | Code | Typical US–type DSM Measure | End Use Impacted | Meets End Use Objective | Load Shape Impact: Peak Impact W/S/Both | Load Shape Impact: Significant Energy Savings | Load Shape Impact: Meets Load Shape Objective | DSM Form | Meets DSM Form Objective | Relative Costs | Bulgaria Equipment Available? |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Motors (> 10 kW) | 201 | replace standard motor w/ high eff. motor | Motors | Yes | Both | Yes | Yes | Str. Consv. | Yes | Medium | Uncertain |
| | 202 | replace failed std. eff. motor w/ high eff. | Motors | Yes | Both | Yes | Yes | Str. Consv. | Yes | Low | Uncertain |
| | 203 | rewind inefficient motor | Motors | Yes | Both | Yes | Yes | Str. Consv. | Yes | Low | Yes |
| | 204 | install variable speed drives | Motors | Yes | Both | Yes | Yes | Str. Consv. | Yes | Med/Hi | Unknown |
| | 205 | replace babbit bearings with roller | Motors | Yes | Both | Small | Yes | Str. Consv. | Yes | Low | Yes |
| | 206 | replace V belts with cog belts | Motors | Yes | Both | Small | Yes | Str. Consv. | Yes | Low/No | Yes |
| | 207 | downsize motors | Motors | Yes | Both | Yes | Yes | Str. Consv. | Yes | Med/Lo | Yes |
| | 208 | high efficiency HVAC motors | HVAC | No | Summer | Yes | No | Str. Consv. | Yes | Medium | Uncertain |
| | 209 | replace efficient motor w/ more efficient | Motors | Yes | Both | Yes | Yes | Str. Consv. | Yes | Medium | Uncertain |
| | 210 | adjust belt tension | Motors | Yes | Both | Yes | Yes | Str. Consv. | Yes | Low/No | Yes |
| | 211 | Survey motor eff., identify ineff. motors | Motors | Yes | Both | Yes | Yes | Str. Consv. | Yes | Eng Mgt | Yes |
| | 212 | check/correct load on each phase | Motors | Yes | Both | Yes | Yes | Str. Consv. | Yes | Eng Mgt | Yes |
| Hydraulics | 401 | downsize motors | Motors | Yes | Both | Yes | Yes | Str. Consv. | Yes | Med/Lo | Yes |
| | 402 | install variable volume pumps | Motors | Yes | Both | Yes | Yes | Str. Consv. | Yes | Medium | Yes |
| Fans | 501 | install variable pitch fan blades | Motors | Yes | Both | Yes | Yes | Str. Consv. | Yes | Med/Lo | Yes |
| | 502 | install inlet/outlet dampers | Motors | Yes | Both | Yes | Yes | Str. Consv. | Yes | Med/Lo | Yes |
| | 503 | bypass timer | Motors | Yes | Both | Yes | Yes | Peak Clip | Yes | Low | Yes |
| | 504 | install variable speed drives on fans | Motors | Yes | Both | Yes | Yes | Str. Consv. | Yes | Med/Hi | Unknown |
| | 505 | install HEPA filters | Motors | Yes | Both | Small | Yes | Str. Consv. | Yes | Low | Uncertain |
| | 506 | install dryer control systems | Process Ht | Yes | Both | Yes | Yes | Str. Consv. | Yes | Low | Uncertain |
| Material Handling | 601 | install energy efficient motors | Motors | Yes | Both | Yes | Yes | Str. Consv. | Yes | Medium | Uncertain |
| | 602 | replace pneum conveyors w/ mechanical | Motors | Yes | Both | Limited | No | Str. Consv. | Yes | High | Uncertain |
| | 603 | install high efficiency blowers | Motors | Yes | Both | Yes | Yes | Str. Consv. | Yes | Medium | Uncertain |
| | 604 | install VSDs on conveyors | Motors | Yes | Both | Yes | Yes | Str. Consv. | Yes | Med/Hi | Unknown |
| Process Cooling | 701 | replace dampers with fan controls | Motors | Yes | Both | Yes | Yes | Str. Consv. | Yes | Med/Lo | Unknown |
| | 702 | retrofit cooling tower fill material | Pumps | Yes | Both | Yes | Yes | Str. Consv. | Yes | High | Uncertain |
| | 703 | use well/ground water | Pumps | Yes | Both | Limited | No | Str. Consv. | Yes | Medium | Uncertain |
| | 704 | install variable speed drives on fans | Motors | Yes | Both | Yes | Yes | Str. Consv. | Yes | Med/Hi | Unknown |
| General Mech. | 801 | install interlocks on equipment | Load Cntl | Yes | Both | Yes | Yes | Peak Clip | Yes | Medium | Uncertain |
| | 802 | convert to hydrofoil agitators | Motors | Yes | Both | Limited | Yes | Str. Consv. | Yes | Med/Hi | Uncertain |
| | 803 | install insulating jackets | Heating | Yes | Both | Small | Yes | Str. Consv. | Yes | Low | Yes |
| | 804 | replace air guns w/ air–airless guns | Comp. | Yes | Both | Limited | Yes | Str. Consv. | Yes | Low | Uncertain |
| | 805 | high efficiency transformers | Transfmr. | Yes | Both | Yes | Yes | Str. Consv. | Yes | Medium | Yes |
| Pumping (Fixed Flow) | 901 | trim pump impellers | Pumps | Yes | Both | Yes | Yes | Str. Consv. | Yes | Medium | Uncertain |
| | 902 | downsize pump | Pumps | Yes | Both | Yes | Yes | Str. Consv. | Yes | Med/Lo | Yes |
| | 903 | install flow–restricting nozzles | Pumps | Yes | Both | Yes | Yes | Str. Consv. | Yes | Med/Lo | Yes |
| | 904 | oversized piping to reduce flow friction | Pumps | Yes | Both | Yes | Yes | Str. Consv. | Yes | Med/Hi | Yes |
| Pumping (Variable Flow) | 1001 | variable speed drive on pump motor | Pumps | Yes | Both | Yes | Yes | Str. Consv. | Yes | Med/Hi | Unknown |
| | 1002 | install flow–restricting nozzles | Pumps | Yes | Both | Yes | Yes | Str. Consv. | Yes | Med/Lo | Yes |
| | 1003 | oversized piping to reduce flow friction | Pumps | Yes | Both | Yes | Yes | Str. Consv. | Yes | Med/Hi | Yes |
| Com–pressed Air | 1101 | institute leak reduction program | Comp. | Yes | Both | Yes | Yes | Str. Consv. | Yes | Eng Mgt | Yes |
| | 1102 | install engineered nozzles | Comp. | Yes | Both | Yes | Yes | Str. Consv. | Yes | Medium | Uncertain |
| | 1103 | reduce operating pressure | Comp. | Yes | Both | Yes | Yes | Str. Consv. | Yes | Low/No | Yes |
| | 1104 | use outside air intake | Comp. | Yes | Both | Yes | Yes | Str. Consv. | Yes | Low | Yes |
| | 1105 | install controller for compressor(s) | Comp. | Yes | Both | Yes | Yes | Peak Clip | Yes | Medium | Uncertain |
| | 1106 | lead/lag controls & rework piping | Comp. | Yes | Both | Yes | Yes | Str. Consv. | Yes | Medium | Yes |
| | 1107 | low pressure blowers & rework piping | Comp. | Yes | Both | Yes | Yes | Str. Consv. | Yes | Med/Hi | Yes |
| | 1108 | low load unloaders/replace pneum.motors/humidity controls | Comp. | Yes | Both | Yes | Yes | Str. Consv. | Yes | Medium | Uncertain |
| | 1109 | replace pneumatic motors & rework pipes | Comp. | Yes | Both | Yes | Yes | Str. Consv. | Yes | Med/Hi | Yes |

# Exhibit 5–7 (continued)
# INDUSTRIAL SECTOR DSM MEASURE SCREENING
# BULGARIA

| DSM Family | Code | Typical US–type DSM Measure | End Use Impacted | Meets End Use Objective | Load Shape Impact: Peak Impact W/S/Both | Load Shape Impact: Significant Energy Savings | Meets Load Shape Objective | DSM Form | Meets DSM Form Objective | Relative Costs | Bulgaria Equipment Available? |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1110 | install VSDs on compressors | Comp. | Yes | Both | Yes | Yes | Str. Consv. | Yes | Med/Hi | Unknown |
| | 1111 | multiplexed compressors | Comp. | Yes | Both | Yes | Yes | Str. Consv. | Yes | Medium | Yes |
| | 1112 | compare system eff. with design specs | Comp. | Yes | Both | Yes | Yes | Str. Consv. | Yes | Eng Mgt | Yes |
| Incand. Lighting | 1201 | HID incandescents | Lighting | Yes | Both | Yes | Yes | Str. Consv. | Yes | Low/Med | Unknown |
| | 1202 | compact fluorescent replacement | Lighting | Yes | Both | Yes | Yes | Str. Consv. | Yes | Low/Med | Yes |
| | 1203 | incandescent to standard fluorescent | Lighting | Yes | Both | Yes | Yes | Str. Consv. | Yes | Low/Med | Yes |
| | 1204 | HID new luminaraire | Lighting | Yes | Both | Yes | Yes | Str. Consv. | Yes | Low/Med | Unknown |
| | 1205 | timeclock, photocell, bypass/delay timer | Lighting | Yes | Both | Yes | Yes | Str. Consv. | Yes | Low/Med | Yes |
| | 1206 | clean fixtures & reflectors | Lighting | Yes | Both | Yes | Yes | Str. Consv. | Yes | Low/No | Yes |
| | 1207 | motion detector: small/large rooms | Lighting | Yes | Both | Yes | Yes | Str. Consv. | Yes | Low/Med | Yes |
| Fluor. | 1301 | replace std (40 watt) tubes with 34 watt | Lighting | Yes | Both | Yes | Yes | Str. Consv. | Yes | Low/Med | Unknown |
| | 1302 | install electronic ballasts | Lighting | Yes | Both | Yes | Yes | Str. Consv. | Yes | Low/Med | Unknown |
| | 1303 | install optical reflectors, delamp | Lighting | Yes | Both | Yes | Yes | Str. Consv. | Yes | Low/Med | Unknown |
| | 1304 | install new T8 fixtures with electronic ballast | Lighting | Yes | Both | Yes | Yes | Str. Consv. | Yes | Low/Med | Unknown |
| | 1305 | timeclock, photocell, bypass/delay timer | Lighting | Yes | Both | Yes | Yes | Str. Consv. | Yes | Low/Med | Yes |
| | 1306 | motion detector: small/large rooms | Lighting | Yes | Both | Yes | Yes | Str. Consv. | Yes | Low/Med | Yes |
| | 1307 | clean fixtures & reflectors | Lighting | Yes | Both | Yes | Yes | Str. Consv. | Yes | Low/No | Yes |
| Other Lighting | 1401 | replace mercury vapor with metal halide | Lighting | Yes | Both | Yes | Yes | Str. Consv. | Yes | Low/Med | Unknown |
| | 1402 | timeclock, photocell, bypass/delay timer | Lighting | Yes | Both | Yes | Yes | Str. Consv. | Yes | Low/Med | Yes |
| | 1403 | motion detector: warehouses | Lighting | Yes | Both | Yes | Yes | Str. Consv. | Yes | Low/Med | Yes |
| | 1404 | retrofit MV with HPS lamp/ballast | Lighting | Yes | Both | Yes | Yes | Str. Consv. | Yes | Low/Med | Unknown |
| | 1405 | HE Lighting System | Lighting | Yes | Both | Yes | Yes | Str. Consv. | Yes | Low/Med | Unknown |
| | 1406 | replace Metal Halide w/HPS retrofit | Lighting | Yes | Both | Yes | Yes | Str. Consv. | Yes | Low/Med | Unknown |
| Space Cooling | 1501 | replace chiller with high efficiency | HVAC | No | Summer | Yes | No | Str. Consv. | Yes | Medium | Uncertain |
| | 1502 | install evaporative cooling system | HVAC | No | Summer | Yes | No | Str. Consv. | Yes | Medium | Uncertain |
| | 1503 | install fully integrated economizer | HVAC | No | Summer | Yes | No | Str. Consv. | Yes | Medium | Uncertain |
| | 1504 | install reflective window film | HVAC | No | Summer | Small | No | Str. Consv. | Yes | Low | Uncertain |
| | 1505 | install energy mgmt system | Load Cntl | Yes | Summer | Yes | Yes | Peak Clip | Yes | Medium | Uncertain |
| Process Heating | 1601 | improve sealing on furnaces and equip. | Process Ht | Yes | Both | Yes | Yes | Str. Consv. | Yes | Eng Mgt | Yes |
| | 1602 | improve insulation on hot equipment | Process Ht | Yes | Both | Yes | Yes | Str. Consv. | Yes | Low | Yes |
| | 1603 | improve process heating controls | Process Ht | Yes | Both | Yes | Yes | Str. Consv. | Yes | Medium | Uncertain |
| | 1604 | install VSDs on kilns | Motors | Yes | Both | Yes | Yes | Str. Consv. | Yes | Med/Hi | Unknown |
| | 1605 | install continuous melting system | Process Ht | Yes | Both | Yes | Yes | Str. Consv. | Yes | Med/Hi | Yes |
| | 1606 | convert electric furnaces to gas | Process Ht | Yes | Both | Yes | Yes | Str. Consv. | Yes | Medium | Yes |
| Refrig– | 1701 | improve control systems | Motors | Yes | Both | Yes | Yes | Str. Consv. | Yes | Eng Mgt | Yes |
| | 1702 | use strip containers on doors | Motors | Yes | Both | Small | Yes | Str. Consv. | Yes | Low | Uncertain |
| | 1703 | install energy efficient compressors | Motors | Yes | Both | Yes | Yes | Str. Consv. | Yes | Medium | Uncertain |
| | 1704 | install electronic variable speed drive | Motors | Yes | Both | Yes | Yes | Str. Consv. | Yes | Med/Hi | Unknown |
| | 1705 | install additional condensers | Motors | Yes | Both | Yes | Yes | Str. Consv. | Yes | Med/Hi | Yes |
| Space Heating | 1801 | replace convective heaters with radiant heaters | Sp. Heat | Yes | Winter | Yes | Yes | Str. Consv. | Yes | Medium | Yes |
| | 1802 | replace with variable air volume (VAV) | Sp. Heat | Yes | Winter | Yes | Yes | Str. Consv. | Yes | Medium | Yes |
| | 1803 | storage heat | Sp. Heat | Yes | Winter | Yes | Yes | Valley Fill | No | Medium | Yes |
| | 1804 | install controls (EMS) on heating system | Sp. Heat | Yes | Winter | Yes | Yes | Peak Clip | Yes | Medium | Uncertain |
| | 1805 | building envelope improvements | Sp. Heat | Yes | Winter | Yes | Yes | Str. Consv. | Yes | Lo/Med | Yes |
| Gas Heat | 2001 | replace electric furnace w/gas furnace | Sp. Heat | Yes | Winter | Yes | Yes | Str. Consv. | Yes | Med/Hi | Yes |
| | 2002 | replace gas furnace w/electric furnace | Sp. Heat | No | Winter | Yes | Yes | Load Build | No | Med/Hi | Yes |
| | 2003 | supplement elect. furnace w/infra–red heating | Sp. Heat | Yes | Winter | Yes | Yes | Str. Consv. | Yes | Medium | Yes |
| Gas Boiler | 2401 | replace electric boilers with gas boilers | Sp.&Wat. | Yes | Winter | Yes | Yes | Str. Consv. | Yes | Med/Hi | Yes |
| | 2402 | replace gas boilers with electric boilers | Sp.&Wat. | No | Winter | Yes | Yes | Load Build | No | Med/Hi | Yes |

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### 5.1.4 DSM Measure Benefit-Cost Analysis

After screening, each measure was subjected to a test of cost-effectiveness. The test used was a test of economic efficiency, called the Total Resource Cost Test (TRC).

First, an estimate of avoided costs is used to provide a supply-side baseline. The estimates of marginal costs described previously in this report (see Exhibit 4-4) were used. In summary, at the low voltage level, the avoided costs are:

$55 per year per kW of peak demand reduction

$0.030 per kWh of energy saved

In the test, a calculation is made of the ratio of life cycle benefits (avoided cost of electricity supply) to life cycle investment costs for the DSM measure. If the ratio is greater than 1.0, the DSM measure is superior to the supply-side baseline.

Based on the pre-screening, the library of industrial DSM measures was customized with Bulgaria-specific DSM measures. The A.I.D.-sponsored energy audits in Bulgaria (and other countries in Eastern Europe) were used as a primary source of additional measures to be considered. Though these audits focused on oil and gas energy efficiency rather than electricity, several measures were clearly identified. These include:

- Optimization of production to meet the demands of the market economy can reduce electrical energy consumption by 10-30%, in those plants that have excess capacity and parallel process lines;
- Improvements to energy monitoring and control, comparing energy to production on a daily basis using low-cost PC-based systems and modern management techniques, can reduce electrical energy consumption by 10% or more;
- Improvements to operations and maintenance of electrical systems, with particular focus on electric motors and drive systems, can save 2% or more;
- Improvements to the operations and maintenance of compressed air systems, including leak repairs, can reduce energy requirements for compressed air by 5-20%;
- Improvements to the operations and maintenance of ammonia refrigeration systems can reduce energy requirements for refrigeration by 5-20%;

- Opportunities exist to reduce peak demand by 5-10% through use of load monitoring and control-systems.

#### 5.1.4.1 End-Use Electricity Consumption Data

Rough approximations for end-use consumption were made to carry out the analysis. Annual energy consumption by residential customers was estimated as 3,000 kWh per year. Industrial customers were assumed to be of average size - 2 MW peak demand and 10,000 MWh per year consumption.

The assumptions for end-use energy consumption are discussed below:

- Lighting: The lighting analysis was performed on a per light basis, while the other end-uses are for total consumption by that end-use. This used a base case of 75 operated for 4 hours per day, 365 days per year, or 110 kWh per year for a 75-Watt lamp. The commercial lighting studies used a base case of a 3x40-Watt fluorescent fixture, operating 8 hours per day, 5 days per week, or 250 kWh per year.

- Refrigerators: Base consumption was developed from the power rating of a 160 liter capacity refrigerator sold in the central department store in Sofia (the "C.U.M." store). The number of hours of operation per year (cycle time) is from a U.S. utility study. The resulting energy consumption is 867 kWh per year.

- Freezers: Consumption in this end-use was assumed to be the same as for refrigerators as these values are usually close.

- Cooking: Electricity use for cooking was assumed to be 200 kWh per year.

- Central and Room Air Conditioning: These end-uses were not estimated because they were eliminated in the qualitative screening as not being appropriate for Bulgaria.

- Space Heating: Hagler, Bailly estimates that electric resistance space heating for an average household in Bulgaria will require approximately 4,500 kWh per year. Most households in large apartment-houses in the cities use district heating instead of this type of system.

- Water Heating: Hagler, Bailly estimates that electric domestic water heating for an average household in Bulgaria will require approximately 1,000 kWh

per year. Most households in large apartment-houses in the cities use district heating instead of this type of system.

- Industrial: Based on the A.I.D.-sponsored audits, Hagler, Bailly developed an estimated typical energy balance for an industrial plant as follows:

| | | |
|---|---|---|
| Motors | 60%, of which: | |
| compressed air | | 1/3 of motor kWh |
| pumps, fans | | 1/3 |
| other | | 1/3 |
| Lighting | 15%, of which: | |
| incandescent | | 1/20 of lighting kWh |
| Other (including process) | 25% | |

The results of the benefit-cost analysis of measures is shown in Exhibit 5-8 for the buildings sector and Exhibit 5-9 for the industrial sector.

## Exhibit 5–8
## BUILDINGS SECTORS (RESIDENTIAL, COMMERCIAL, INSTITUTIONAL) DSM MEASURES
## PRELIMINARY COST–BENEFIT ANALYSIS
## BULGARIA

| | | | Annual Energy | | | Peak Demand | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| DSM Family | Code | Typical US–type DSM Measure | Base Annual Energy Consumption | Percent Savings From DSM Measure | Annual Energy Savings | Base Peak Demand Level | Percent Savings From DSM Measure | Winter Demand Savings | Measure Lifetime | Value Of Peak & Energy Savings | Cost per unit | Program Costs (Percent) | Total Resource Cost Test |
| Building Heating | 101 | Increase Ceiling Insulation | 3,000 | 6.5% | 195 | 3.0 | 6.5% | 0.2 | 30 | $172 | $150 | 20% | 0.95 |
| | 102 | Increase Wall Insulation | 3,000 | 29.0% | 870 | 3.0 | 29.0% | 0.9 | 30 | 767 | 2,000 | 20% | 0.32 |
| | 103 | Insulate Doors | 3,000 | 0.7% | 21 | 3.0 | 0.7% | 0.0 | 20 | 17 | 75 | 20% | 0.19 |
| | 104 | Install Storm Windows | 3,000 | 9.0% | 270 | 3.0 | 9.0% | 0.3 | 20 | 215 | 300 | 20% | 0.60 |
| | 105 | Add Plastic to Windows | 3,000 | 4.8% | 144 | 3.0 | 4.8% | 0.1 | 3 | 33 | 5 | 20% | 5.58 |
| | 106 | Caulking/Weatherstripping | 3,000 | 12.0% | 360 | 3.0 | 12.0% | 0.4 | 5 | 128 | 125 | 20% | 0.85 |
| | 107 | Install air source heat pump | 3,000 | 47.5% | 1,425 | 3.0 | 47.5% | 1.4 | 15 | 1,013 | Data Req. | 20% | N.A. |
| | 108 | Add Thermostat/Regulator | 3,000 | 10.0% | 300 | 3.0 | 10.0% | 0.3 | 20 | 239 | 30 | 20% | 6.63 |
| | 109 | Thermal energy storage | 3,000 | –0.1% | (3) | 3.0 | 100.0% | 3.0 | 20 | 1,544 | N.A. | N.A. | N.A. |
| | 110 | Fuel Conversion: Electric to Gas | 3,000 | 100.0% | 3,000 | 3.0 | 100.0% | 3.0 | 30 | 2,644 | 1,206 | 0% | 2.19 |
| | 111 | Direct load control – heat | 3,000 | 0.5% | 3,000 | 3.0 | 50.0% | 3.0 | 30 | 1,000 | 200 | 20% | 4.16 |
| Elect. Water Heating | 201 | Water Heater & Pipe Insulation | 1,000 | 12.7% | 127 | 0.2 | 8.0% | 0.0 | 10 | 32 | 18 | 20% | 1.47 |
| | 202 | Flow restrictors | 1,000 | 10.0% | 100 | 0.2 | 10.0% | 0.0 | 5 | 17 | 8 | 20% | 1.78 |
| | 203 | Add Timer to Operate WH Off–Peak | 1,000 | 10.0% | 100 | 0.2 | 33.0% | 0.1 | 13 | 52 | 20 | 20% | 2.16 |
| | 204 | WH Thermostat | 1,000 | 4.9% | 49 | 0.2 | 4.9% | 0.0 | 13 | 16 | 1 | 20% | 13.08 |
| | 205 | Water Heater (Direct Load Control) | 1,000 | –2.0% | (20) | 0.2 | 67.0% | 0.1 | 15 | 57 | 90 | 20% | 0.52 |
| | 206 | Storage Water Heater | 1,000 | –5.0% | (50) | 0.2 | 100.0% | 0.2 | 13 | 74 | Data Req. | 20% | N.A. |
| | 207 | Electric to Gas Water Heater | 1,000 | 100.0% | 1,000 | 0.2 | 100.0% | 0.2 | 10 | 277 | Data Req. | 20% | N.A. |
| Cooking | 301 | New stove – spiral heating elements | 200 | 20.0% | 40 | 0.100 | 20.0% | 0.020 | 20 | 22 | Data Req. | 20% | N.A. |
| | 302 | Electric Cooking to Gas Cooking | 200 | 100.0% | 200 | 0.100 | 100.0% | 0.100 | 15 | 96 | Data Req. | 20% | N.A. |
| Refrig. | 401 | High Efficiency Refrigerator–Import | 867 | 38.4% | 333 | 0.103 | 38.4% | 0.040 | 15 | 102 | 285 | 20% | 0.30 |
| | 402 | High Efficiency Refrigerator–Domestic | 867 | 38.4% | 333 | 0.103 | 38.4% | 0.040 | 15 | 102 | 35 | 20% | 2.42 |
| Lighting | 501 | Res. Incandescent to Compact Fluor. | 110 | 76.0% | 83 | 0.020 | 76.0% | 0.015 | 6 | 16 | 5 | 20% | 2.67 |
| | 502 | Res. Energy Eff. Incandescent | 117 | 8.3% | 10 | 0.022 | 8.3% | 0.002 | 1 | 0 | 0 | 20% | 3.25 |
| | 503 | Res. Incandescent to Std. Fluor. Fixture | 117 | 50.0% | 58 | 0.022 | 50.0% | 0.011 | 8 | 14 | 3 | 20% | 3.74 |
| | 504 | Commercial Incand. to Compact Fluor. | 166 | 76.0% | 126 | 0.068 | 76.0% | 0.051 | 2 | 13 | 5 | 20% | 2.10 |
| | 505 | Fixture replace w/ EELamps & EEBal. | 250 | 29.0% | 72 | 0.096 | 29.0% | 0.028 | 12 | 28 | Data Req. | 20% | N.A. |
| | 506 | Fixture replace w/ Delamping & Refl. | 250 | 64.5% | 161 | 0.096 | 64.5% | 0.062 | 12 | 62 | Data Req. | 20% | N.A. |
| | 507 | Day Lighting Control | 250 | 15.0% | 37 | 0.096 | 15.0% | 0.014 | 12 | 14 | N.A. | 20% | N.A. |
| | 508 | High Efficiency Lamps | 250 | 20.4% | 51 | 0.096 | 20.4% | 0.020 | 12 | 20 | Data Req. | 20% | N.A. |
| | 509 | EMS Lighting | 250 | 21.2% | 53 | 0.096 | 21.2% | 0.020 | 12 | 20 | Data Req. | 20% | N.A. |
| | 510 | Occupancy Sensors | 250 | 15.0% | 37 | 0.096 | 15.0% | 0.014 | 12 | 14 | Data Req. | 20% | N.A. |
| | 511 | Mercury vapor to HPS | 312 | 36.6% | 114 | 0.038 | 36.6% | 0.014 | 12 | 31 | Data Req. | 20% | N.A. |
| | 512 | Incandescent to HPS | 166 | 75.0% | 125 | 0.068 | 75.0% | 0.051 | 12 | 49 | Data Req. | 20% | N.A. |
| | 513 | Incandescent to Metal Halide | 166 | 84.0% | 140 | 0.034 | 84.0% | 0.028 | 12 | 43 | Data Req. | 20% | N.A. |
| | 514 | Incandescent to Fluorescent | 166 | 50.0% | 83 | 0.034 | 50.0% | 0.017 | 12 | 26 | Data Req. | 20% | N.A. |

RES_CB1.WK1

## Exhibit 5–9
## INDUSTRIAL SECTOR DSM PROGRAM
## PRELIMINARY COST–BENEFIT ANALYSIS
## BULGARIA

| Code | Program | Annual Energy | | | Peak Demand | | | Typical Measure Lifetime | Value Of Peak & Energy Savings | Typical Approx. Cost per unit | Typical Admin. Costs | Total Resource Cost |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Typical Base Annual Energy Consumption MWh | Typical Savings From DSM Measure pct | Typical Annual Energy Savings MWh | Typical Base Peak Demand Level kW | Typical Savings From DSM Measure pct | Typical Winter Demand Savings kW | yrs | US$ | US$ | pct | test |
| P101 | Energy/production audit | 10,000 | 10% | 1,000 | 2,000 | 10% | 200 | 10 | $277,000 | $50,000 | 20% | 4.62 |
| P102 | Motor O&M | 6,000 | 3% | 180 | 1,200 | 3% | 36 | 10 | 49,000 | 20,000 | 20% | 2.04 |
| P103 | Compressed Air O&M | 2,000 | 2% | 40 | 400 | 2% | 8 | 10 | 11,000 | 10,000 | 20% | 0.92 |
| P104 | High efficiency motors | 6,000 | 3% | 180 | 1,200 | 3% | 36 | 10 | 49,000 | 50,000 | 20% | 0.82 |
| P105 | Drives systems, rotating equipt | 6,000 | 3% | 180 | 1,200 | 3% | 36 | 10 | 49,000 | 50,000 | 20% | 0.82 |
| P106 | Lighting efficiency | 1,500 | 5% | 75 | 300 | 5% | 15 | 10 | 20,000 | 20,000 | 20% | 0.83 |
| P107 | Improve new installations | 2,000 | 20% | 400 | 400 | 20% | 80 | 20 | 153,000 | 500,000 | 20% | 0.26 |
| P108 | Fuel switching | 1,000 | 100% | 1,000 | 200 | 100% | 200 | 20 | 383,000 | 750,000 | 20% | 0.43 |
| P109 | Interruptible/self–generation | 10,000 | 5% | 500 | 2,000 | 30% | 600 | 10 | 320,000 | 300,000 | 20% | 0.89 |
| P110 | Direct load control | 10,000 | 1% | 100 | 2,000 | 10% | 200 | 10 | 94,000 | 50,000 | 20% | 1.57 |
| P111 | Energy management system | 10,000 | 5% | 500 | 2,000 | 10% | 200 | 10 | 175,000 | 50,000 | 20% | 2.92 |

IND_CB.WK1

### 5.1.4.2 Example DSM Measure Analysis: Compact Fluorescent Lamps (CFL)

Incandescent lamps are widely used in Bulgaria, both in households and other applications. Replacing incandescent lamps with compact fluorescent lamps (CFL) has been found to be cost-effective in certain situations. The CFL has a much higher capital cost, but use only 1/4 as much energy (or peak demand), and CFL bulbs also last up to ten times longer.

While this evaluation appears to be easy, several questions need to be answered before a CFL DSM measure can be evaluated. For example,

- What is the wattage of the old bulb being replaced? An 18 watt CFL might replace an old bulb of between 25-100 watts, so savings could be more or less.
- What proportion of bulbs replaced will normally be operated during peak demand periods, so that it is appropriate to take credit for the peak demand savings?
- How many hours per year is the bulb operated? This is the most critical factor in the decision, since it determines the energy savings resulting from this change.

Exhibit 5-10 illustrates the calculation of the economic benefit-cost ratio (TRC) for the CFL, under a specific set of assumptions. The case is a residential application, where the bulb is replacing a 75 watt incandescent and is in use 4 hours per day. Under these assumptions, the TRC is more than 2.5. Any value much more than 1.0 indicates a good DSM measure. But if the lamp were only used 2 hours per day, the CFL measure would be marginal.

## Exhibit 5–10
## COMPACT FLUORESCENT LAMP RESIDENTIAL DSM MEASURE

| SAVINGS | Value | Units | Comment |
|---|---|---|---|
| **Peak Demand Savings** | | | |
| Base (Incandescent) | 75 | Watts | |
| Compact Fluorescent | 18 | Watts | |
| Savings | 57 | Watts | |
| Proportion on During Peak Hours | 27% | | |
| Diversified Peak Reduction | 15.39 | Watts | |
| Peak Demand Savings | $55.00 | Per kW | |
| Value of Peak Savings | $4.23 | | Present Value Over Life of Measure |
| **Energy Savings** | | | |
| Hours of Operation | 4 | Hours/day | |
| Annual Energy Reduction | 83.22 | kWh | 4 hours per day x 365 days x 57 Watts = 83.22 kWh |
| Lifetime of Bulb | 6 | Years | 10,000 hour life at 1,420 hrs/yr |
| Lifetime Energy Reduction | 499.32 | kWh | 6 years x 83.22 kWh/year |
| Energy Savings | $0.030 | Per kWh | |
| Value of Energy Savings | $12.46 | | Present Value Over Life of Measure |
| **Total Value of Savings** | **$16.69** | | **Peak Savings + Energy Savings** |
| **COSTS** | | | |
| Incremental Costs | $5.00 | | |
| Program Administration Costs | $1.00 | | Typical Program Cost Estimate OF 20% |
| Total Costs | $6.00 | | |
| **Total Resource Cost Test** | **2.78** | | **Ratio of Total Savings to Costs.** |

CFL.WK1

## 5.2 ILLUSTRATIVE DSM PROGRAM FOR BULGARIA

### 5.2.1 Selection of Illustrative DSM Program for Bulgaria

Based on the results of the screening, the DSM measures which appear best able to satisfy the selection criteria for Bulgaria include:

- Low-cost improvements in homes heated with electricity, such as window coverings, weatherstripping, and thermostats
- Low-cost improvements in homes where hot water is heated with electricity, such as improved insulation, flow restrictors, and thermostats
- Retrofit of some incandescent lighting with fluorescent in homes,
- High-efficiency refrigerators,
- Direct load control in the residential and industrial sectors,
- Industrial management, technical, production and energy audits,
- Industrial operations and maintenance improvements,
- Interruptible service and expanded self-generation in industry,
- Computer-based energy management (load monitoring and control) systems in industry.

These measures were assembled into the "Illustrative DSM Program," and were carried to the next stage of analysis.

### 5.2.2 Estimate of Potential Impact of the Illustrative DSM Program

Next, the Illustrative DSM Program was evaluated for potential peak demand reduction and energy savings, scaling up to the level of the NEK system. Three levels of potential DSM impacts were considered in this step: Technical/Economic Potential, Market Potential, and DSM Program Potential. The three levels are described in Exhibit 5-11 and discussed below.

**Exhibit 5-11**
**Evaluating DSM Potential**

Technical/Economic Potential

Which DSM measures are both technically applicable and economically feasible?

What savings (kW and kWh) are possible from these DSM measures?

Market Potential

What proportion of cost-effective DSM measures will be ultimately accepted by consumers on their own?

How long will it take for them to accept them?

What savings (kW and kWh) will result?

Illustrative DSM Program Potential

What proportion of cost-effective DSM measures will be ultimately accepted by consumers, if the utility provides appropriate incentives through a DSM program?

How long will it take for them to accept them?

What savings (kW and kWh) will result?

### 5.2.2.1 Technical/Economic Potential

Technical/economic potential assesses the energy savings and coincident peak demand savings possible if the commercially available, technically applicable, and economically feasible DSM measures were fully implemented. The analysis was carried out at the sector

level (industry or buildings). Based on the data sources available to us (as listed previously), we estimated the percentage savings that would result from implementing the measures.

The estimates of the technical/economic potential are summarized in Exhibit 5-12. In summary, the technical/economic potential for electric energy efficiency measures in Bulgaria amounts to:

Peak demand reduction of more than 2,800 MW (48% of current maximum)

Energy savings of more than 7 TWh (29% of current consumption)

A "supply curve" is useful to illustrate the quantity of a good available at various prices. An energy efficiency supply curve plots the various technical measures in rank order on the basis of their cost of conserved energy (CCE, $/kWh). The CCE for each measure is plotted vs. the technical/economic potential of the measure (GWh/year). The curve only shows technologies which have a CCE less than the estimated marginal cost of energy supply (about $0.03/kWh).

The supply curve of technical/economic potential for measures in the buildings sector is shown in Exhibit 5-13. Several measures appear attractive, led by commercial lighting reflectors.

Exhibit 5-14 illustrates the supply curve for the industrial sector. Energy and production management audits (covering not only electricity consumption but also the organization and management of the production process) are most attractive, flowed by computer energy management systems.

The industrial curve includes two load management technologies that limit peak demand (MW) and are expected to be cost-effective. Because these measures are designed to reduce peak demand, rather than save energy, their CCE is higher than the cost of energy supply.

## Exhibit 5–12
## ELECTRIC ENERGY EFFICIENCY FOR BULGARIA
## ESTIMATE OF TECHNICAL POTENTIAL
## FOR SELECTED MEASURES

| Sector | Functional area – Program element | TECHNICAL POTENTIAL | | | | | |
|---|---|---|---|---|---|---|---|
| | | Annual Energy | | | Peak Demand | | |
| | | Base Annual Energy Consumption GWh | Percent Savings From DSM Measure | Annual Energy Savings GWh | Base Peak Demand Level MW | Percent Savings From DSM Measure | Winter Demand Savings MW |
| Bldg | Window coverings | 1,800 | 5% | 90 | 600 | 5% | 30 |
| Bldg | Caulking, weatherstripping | 1,800 | 5% | 90 | 600 | 5% | 30 |
| Bldg | Thermostat | 1,800 | 10% | 180 | 600 | 10% | 60 |
| Bldg | Heating – convert from electric to gas | 1,800 | 100% | 1,800 | 600 | 100% | 600 |
| Bldg | Hot water insulation | 1,500 | 5% | 75 | 300 | 5% | 15 |
| Bldg | Flow restrictors | 1,500 | 5% | 75 | 300 | 0% | 3 |
| Bldg | Water heater timer | 1,500 | 5% | 75 | 300 | 5% | 15 |
| Bldg | Water heater controls | 1,500 | 5% | 75 | 300 | 5% | 15 |
| Bldg | High efficiency refrigerator | 2,601 | 30% | 780 | 309 | 30% | 93 |
| Bldg | Fluorescent lighting (residential) | 327 | 70% | 229 | 61 | 70% | 43 |
| Bldg | Fluorescent lighting (commercial) | 1,500 | 30% | 450 | 288 | 30% | 86 |
| Bldg | Direct load control | 12,000 | 1% | 120 | 2,000 | 15% | 300 |
| **Bldg** | **Subtotal** | **12,000** | **31%** | **3,679** | **2,000** | **51%** | **1,020** |
| Indus | Energy/production audit | 14,000 | 10% | 1,400 | 4,000 | 10% | 400 |
| Indus | Motor O&M | 8,400 | 3% | 252 | 2,400 | 3% | 72 |
| Indus | Compressed Air O&M | 2,800 | 2% | 56 | 800 | 2% | 16 |
| Indus | High efficiency motors | 8,400 | 3% | 252 | 2,400 | 3% | 72 |
| Indus | Drive systems, rotating loads | 8,400 | 3% | 252 | 2,400 | 3% | 72 |
| Indus | Lighting efficiency | 2,100 | 5% | 105 | 600 | 5% | 30 |
| Indus | Interruptible/self–generation | 14,000 | 5% | 700 | 4,000 | 30% | 1,200 |
| Indus | Direct load control | 14,000 | 1% | 140 | 4,000 | 10% | 400 |
| Indus | Energy management system | 14,000 | 5% | 700 | 4,000 | 10% | 400 |
| **Indus** | **Subtotal** | **14,000** | **28%** | **3,857** | **4,000** | **47%** | **1,862** |
| | **Total** | **26,000** | **29%** | **7,536** | **6,000** | **48%** | **2,882** |

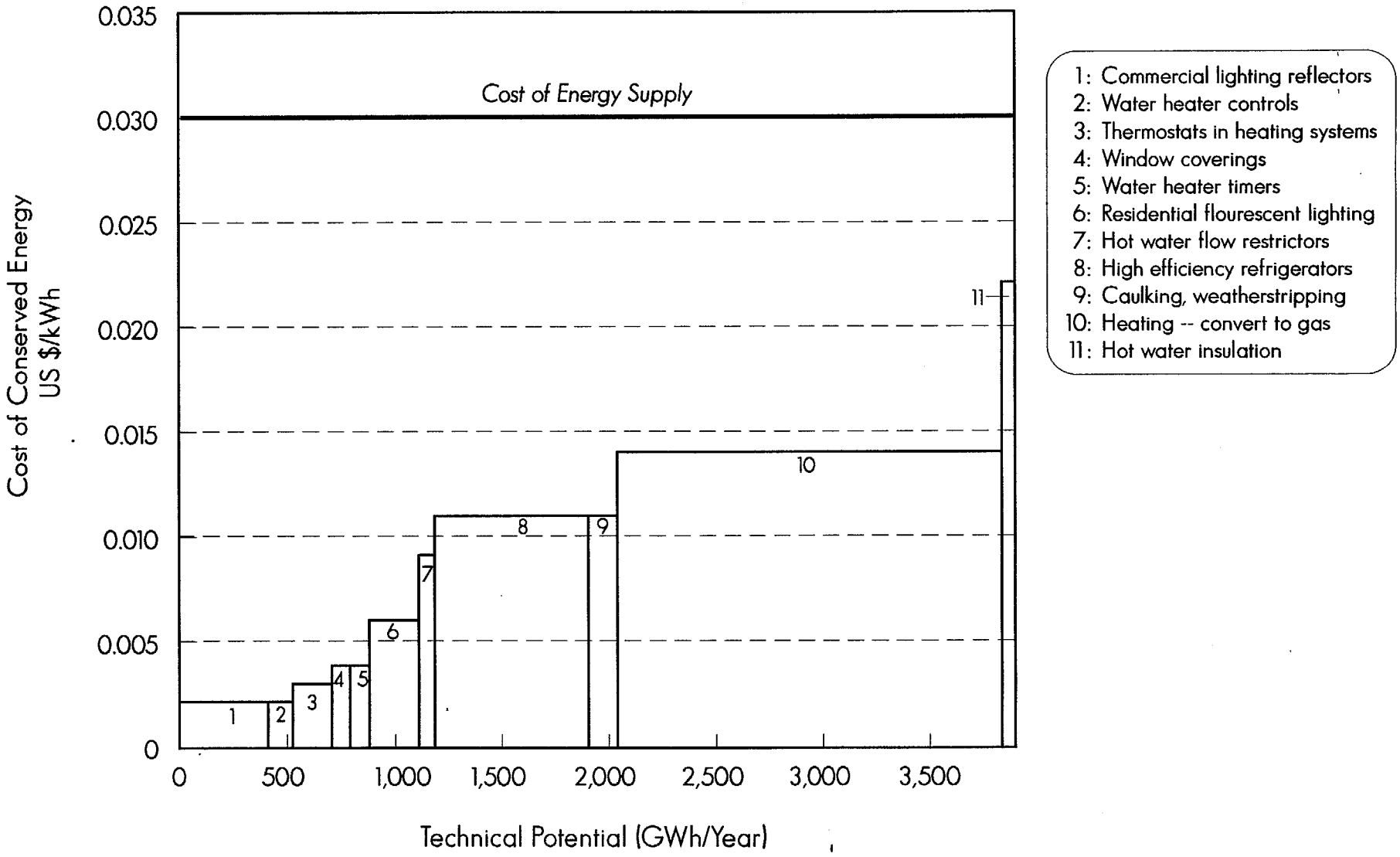
DSM_TECH.WK1

Note: totals adjusted to account for overlapping

Exhibit 5-13

**Bulgaria**

**Supply Curve -- Technical/Economic Potential (Buildings Sector)**

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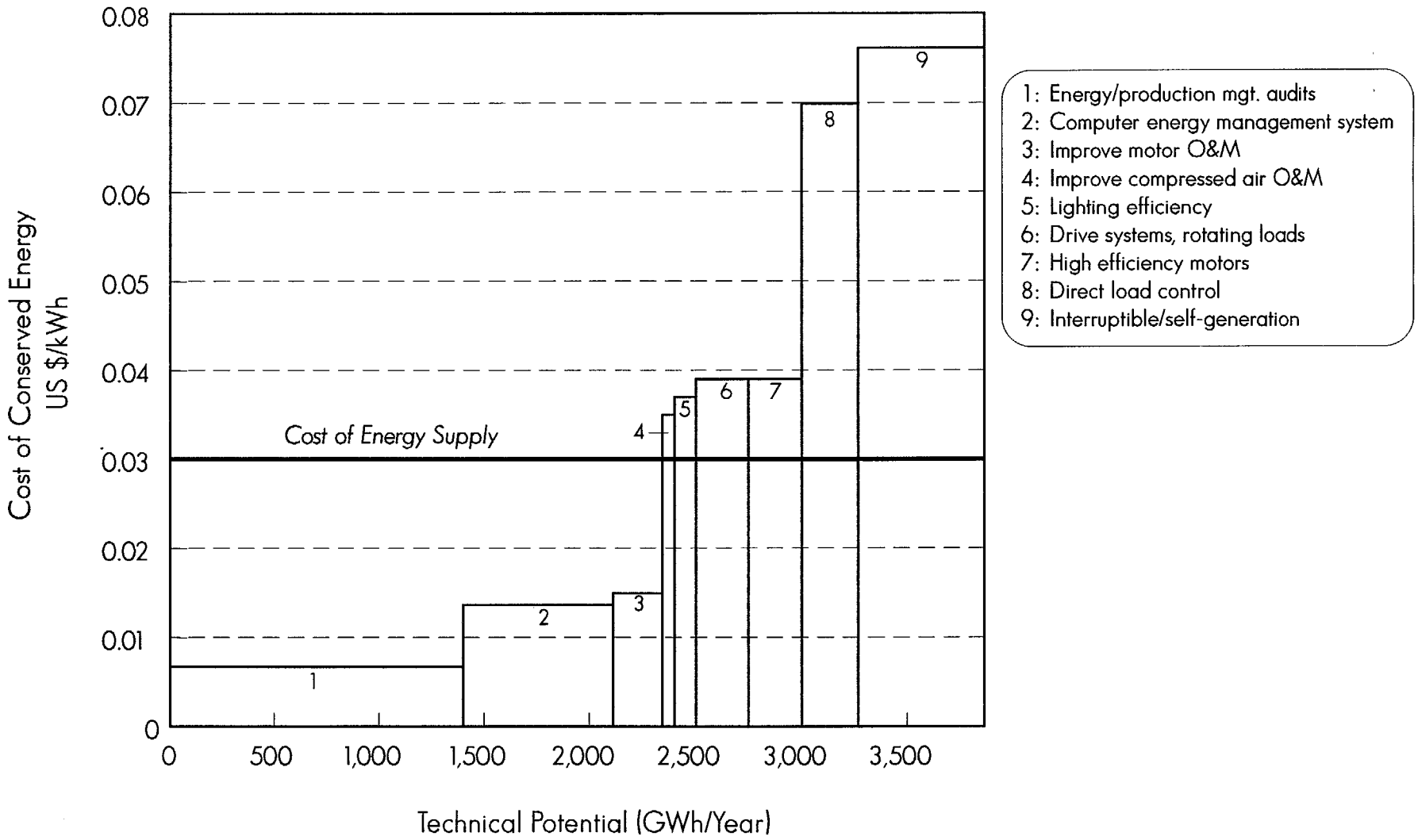
# Exhibit 5-14
## Bulgaria
## Supply Curve -- Technical/Economic Potential (Industry Sector)




319

#### 5.2.2.2 Market Potential

Market potential assesses the likelihood that the technical/economic potential will in fact be realized, based on normal market forces alone, such as electricity prices and consumer behavior. Some of these market forces influencing market potential in Bulgaria are listed in Exhibit 5-15.

Market potential depends on decision maker preferences. A DSM measure that is technically feasible and physically applicable may not be considered cost-effective by different individual home, building, or factory decision makers. Usually decision makers in the same market segment, evaluating the same DSM measure at a given levelized cost may or may not consider it cost-effective to install because of different investment preferences and acceptance criteria.

Market potential indicates the fraction of cost-effective DSM measures that will actually be undertaken by consumers. There are many reasons why even cost-effective DSM measures are not implemented: alternative uses of capital, severe limitations on the availability of capital, disinterest in energy conservation, management focus on other concerns or crises, differing opinions regarding other product attributes, perceptions of technical risk, lack of knowledge of the measure, and numerous other normal market frictions and transaction costs which result in a lower number of DSM measures actually being undertaken than are cost-effective.

**Exhibit 5-15**
**Factors Influencing Investments**
**In Energy Efficiency In Bulgaria**

**Financial Constraints:** There may be insufficient capital available, or the financial risk for energy efficiency may be perceived as being too high. A survey of the 106 largest Bulgarian electrical customers was carried out in December 1992 by DBC. Lack of financing was identified as the key reason for not undertaking energy efficiency investments by 53% of the firms who responded.

**Equipment Availability:** High efficiency equipment may not be available, or other technological limitations may exist. This was cited as the reason for not undertaking energy efficiency investments by 25% of the firms in the Bulgarian survey.

**Subsidized Energy Prices:** Energy prices may not provide the consumer with a sufficient price signal to justify energy efficiency investments. Low electricity prices was identified as the reason for not investing in energy efficiency by approximately 9% of the firms responding to the survey.

**Lack of Information:** Energy users may not be aware of energy efficiency opportunities or may not know how to get the measure implemented.

**Non-Economic Behavior:** Consumers may not make strictly economic behavior but make choices according to other considerations.

**Ownership:** Renters may pay the utility bill, but are unwilling to make improvements to buildings owned by landlords or the state.

Market potential indicates what would happen without a utility-sponsored DSM program.

The estimates of the market potential are shown in Exhibit 5-16. The estimates are based on assumptions regarding market penetration for each measure. These assumptions show low rates of market penetration achieved over a 10-20 year period, consistent with experience in the U.S. and developing countries. In summary, we estimate that the market potential for DSM measures in Bulgaria amounts to 5-7% of the technical/economic potential:

> Peak demand reduction of 150 MW (about 2% of current maximum load from industrial and buildings sectors)
>
> Energy savings of 590 GWh (2% of current consumption by industrial and buildings sectors)

The annual projection of peak demand reduction in the base case is shown in Exhibit 5-17. As indicated, peak demand is reduced by 15 MW in 5 years, 87 MW in 10 years, and 151 MW in 20 years.

The annual projection of energy savings in the base case is shown in Exhibit 5-18. The exhibit shows that energy consumption is reduced by 51 GWh per year in 5 years, 308 GWH per year in 10 years, and 560 GWh per year in 20 years.

## Exhibit 5–16
## ELECTRIC ENERGY EFFICIENCY IN BULGARIA
## ESTIMATED MARKET ACCEPTANCE WITHOUT DSM

| Sector | Functional area – Program element | Technical Potential | | Market Penetration | | Market Potential | |
|---|---|---|---|---|---|---|---|
| | | Annual Energy Savings GWh | Winter Demand Savings MW | Final Market pct | Time to Final Market yrs | Annual Energy Savings GWh | Winter Demand Savings MW |
| Bldg | Window coverings | 90 | 30 | 10% | 10 | 9 | 3 |
| Bldg | Caulking, weatherstripping | 90 | 30 | 10% | 10 | 9 | 3 |
| Bldg | Thermostat | 180 | 60 | 10% | 10 | 18 | 6 |
| Bldg | Heating – convert from electric to gas | 1,800 | 600 | 0% | 20 | 0 | 0 |
| Bldg | Hot water insulation | 75 | 15 | 10% | 10 | 8 | 2 |
| Bldg | Flow restrictors | 75 | 3 | 10% | 10 | 8 | 0 |
| Bldg | Water heater timer | 75 | 15 | 10% | 10 | 8 | 2 |
| Bldg | Water heater controls | 75 | 15 | 10% | 10 | 8 | 2 |
| Bldg | High efficiency refrigerator | 780 | 93 | 20% | 20 | 156 | 19 |
| Bldg | Fluorescent lighting (residential) | 229 | 43 | 10% | 10 | 23 | 4 |
| Bldg | Fluorescent lighting (commercial) | 450 | 86 | 10% | 10 | 45 | 9 |
| Bldg | Direct load control | 120 | 300 | 0% | 20 | 0 | 0 |
| **Bldg** | **Subtotal** | **3,679** | **1,020** | | | **290** | **48** |
| | Savings as pct. of technical potential | | | | | 7.9% | 4.7% |
| | Savings as pct. of current consumption | | | | | 3.4% | 2.0% |
| Indus | Energy/production audit | 1,400 | 400 | 10% | 10 | 140 | 40 |
| Indus | Motor O&M | 252 | 72 | 10% | 10 | 25 | 7 |
| Indus | Compressed Air O&M | 56 | 16 | 10% | 10 | 6 | 2 |
| Indus | High efficiency motors | 252 | 72 | 10% | 10 | 25 | 7 |
| Indus | Drive systems, rotating loads | 252 | 72 | 10% | 10 | 25 | 7 |
| Indus | Lighting efficiency | 105 | 30 | 10% | 10 | 11 | 3 |
| Indus | Interruptible/self–generation | 700 | 1,200 | 0% | 20 | 0 | 0 |
| Indus | Direct load control | 140 | 400 | 0% | 20 | 0 | 0 |
| Indus | Energy management system | 700 | 400 | 10% | 10 | 70 | 40 |
| **Indus** | **Subtotal** | **3,857** | **1,862** | | | **302** | **106** |
| | Savings as pct. of technical potential | | | | | 7.8% | 5.7% |
| | Savings as pct. of current consumption | | | | | 1.5% | 2.7% |
| | **Total** | **7,536** | **2,882** | | | **592** | **154** |
| | Savings as pct. of technical potential | | | | | 7.9% | 5.4% |
| | Savings as pct. of current consumption | | | | | 2.1% | 2.4% |

DSM_MKT.WK1

Note: totals adjusted to account for overlapping

## Exhibit 5–17
## Projection of Market Penetration
## BASE CASE – NO DSM
## Peak Demand Reduction, MW

| Functional area – Program element | Year 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **BUILDINGS:** | | | | | | | | | | | | | | | | | | | | |
| Window coverings | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| Caulking, weatherstripping | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| Thermostat | 0 | 0 | 0 | 0 | 1 | 1 | 2 | 2 | 3 | 4 | 4 | 5 | 5 | 6 | 6 | 6 | 6 | 6 | 6 | 6 |
| Heating – convert from electric to gas | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Hot water insulation | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| Flow restrictors | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Water heater timer | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| Water heater controls | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| High efficiency refrigerator | 0 | 0 | 0 | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
| Incandescent to fluorescent | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 2 | 2 | 3 | 3 | 3 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 |
| Other lighting upgrades | 0 | 0 | 0 | 0 | 1 | 2 | 3 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 9 | 9 | 9 | 9 | 9 | 9 |
| Direct load control | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Subtotal, Buildings** | **0** | **0** | **1** | **2** | **4** | **8** | **12** | **16** | **19** | **23** | **27** | **31** | **35** | **39** | **40** | **41** | **42** | **43** | **44** | **45** |
| **INDUSTRY:** | | | | | | | | | | | | | | | | | | | | |
| Energy/production audit | 0 | 0 | 1 | 2 | 4 | 8 | 12 | 16 | 20 | 24 | 28 | 32 | 36 | 40 | 40 | 40 | 40 | 40 | 40 | 40 |
| Motor O&M | 0 | 0 | 0 | 0 | 1 | 1 | 2 | 3 | 4 | 4 | 5 | 6 | 6 | 7 | 7 | 7 | 7 | 7 | 7 | 7 |
| Compressed Air O&M | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| High efficiency motors | 0 | 0 | 0 | 0 | 1 | 1 | 2 | 3 | 4 | 4 | 5 | 6 | 6 | 7 | 7 | 7 | 7 | 7 | 7 | 7 |
| Drive systems, rotating loads | 0 | 0 | 0 | 0 | 1 | 1 | 2 | 3 | 4 | 4 | 5 | 6 | 6 | 7 | 7 | 7 | 7 | 7 | 7 | 7 |
| Lighting efficiency | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| Interruptible/self–generation | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Direct load control | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Energy management system | 0 | 0 | 1 | 2 | 4 | 8 | 12 | 16 | 20 | 24 | 28 | 32 | 36 | 40 | 40 | 40 | 40 | 40 | 40 | 40 |
| **Subtotal, Industry** | **1** | **1** | **3** | **5** | **11** | **21** | **32** | **42** | **53** | **64** | **74** | **85** | **96** | **106** | **106** | **106** | **106** | **106** | **106** | **106** |
| **Total, Bulgaria** | **1** | **2** | **4** | **7** | **15** | **29** | **44** | **58** | **73** | **87** | **102** | **116** | **131** | **145** | **146** | **147** | **148** | **149** | **150** | **151** |
| **Benefits (US$000)** | **40** | **96** | **200** | **399** | **798** | **1,597** | **2,395** | **3,194** | **3,992** | **4,790** | **5,589** | **6,387** | **7,186** | **7,984** | **8,035** | **8,086** | **8,137** | **8,188** | **8,239** | **8,290** |

BSE_MW.WK1

32

## Exhibit 5–18
## Projection of Market Penetration
## BASE CASE – NO DSM
## Energy savings, GWh/yr

| Functional area – Program element | Year 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **BUILDINGS:** | | | | | | | | | | | | | | | | | | | | |
| Window coverings | 0 | 0 | 0 | 0 | 1 | 2 | 3 | 4 | 5 | 5 | 6 | 7 | 8 | 9 | 9 | 9 | 9 | 9 | 9 | 9 |
| Caulking, weatherstripping | 0 | 0 | 0 | 0 | 1 | 2 | 3 | 4 | 5 | 5 | 6 | 7 | 8 | 9 | 9 | 9 | 9 | 9 | 9 | 9 |
| Thermostat | 0 | 0 | 0 | 1 | 2 | 4 | 5 | 7 | 9 | 11 | 13 | 14 | 16 | 18 | 18 | 18 | 18 | 18 | 18 | 18 |
| Heating – convert from electric to gas | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Hot water insulation | 0 | 0 | 0 | 0 | 1 | 2 | 2 | 3 | 4 | 5 | 5 | 6 | 7 | 8 | 8 | 8 | 8 | 8 | 8 | 8 |
| Flow restrictors | 0 | 0 | 0 | 0 | 1 | 2 | 2 | 3 | 4 | 5 | 5 | 6 | 7 | 8 | 8 | 8 | 8 | 8 | 8 | 8 |
| Water heater timer | 0 | 0 | 0 | 0 | 1 | 2 | 2 | 3 | 4 | 5 | 5 | 6 | 7 | 8 | 8 | 8 | 8 | 8 | 8 | 8 |
| Water heater controls | 0 | 0 | 0 | 0 | 1 | 2 | 2 | 3 | 4 | 5 | 5 | 6 | 7 | 8 | 8 | 8 | 8 | 8 | 8 | 8 |
| High efficiency refrigerator | 0 | 1 | 2 | 4 | 8 | 16 | 23 | 31 | 39 | 47 | 55 | 62 | 70 | 78 | 86 | 94 | 101 | 109 | 117 | 125 |
| Incandescent to fluorescent | 0 | 0 | 1 | 1 | 2 | 5 | 7 | 9 | 11 | 14 | 16 | 18 | 21 | 23 | 23 | 23 | 23 | 23 | 23 | 23 |
| Other lighting upgrades | 0 | 1 | 1 | 2 | 5 | 9 | 14 | 18 | 23 | 27 | 32 | 36 | 41 | 45 | 45 | 45 | 45 | 45 | 45 | 45 |
| Direct load control | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Subtotal, Buildings** | **1** | **3** | **5** | **11** | **21** | **42** | **64** | **85** | **106** | **127** | **148** | **170** | **191** | **212** | **220** | **228** | **235** | **243** | **251** | **259** |
| **INDUSTRY:** | | | | | | | | | | | | | | | | | | | | |
| Energy/production audit | 1 | 2 | 4 | 7 | 14 | 28 | 42 | 56 | 70 | 84 | 98 | 112 | 126 | 140 | 140 | 140 | 140 | 140 | 140 | 140 |
| Motor O&M | 0 | 0 | 1 | 1 | 3 | 5 | 8 | 10 | 13 | 15 | 18 | 20 | 23 | 25 | 25 | 25 | 25 | 25 | 25 | 25 |
| Compressed Air O&M | 0 | 0 | 0 | 0 | 1 | 1 | 2 | 2 | 3 | 3 | 4 | 4 | 5 | 6 | 6 | 6 | 6 | 6 | 6 | 6 |
| High efficiency motors | 0 | 0 | 1 | 1 | 3 | 5 | 8 | 10 | 13 | 15 | 18 | 20 | 23 | 25 | 25 | 25 | 25 | 25 | 25 | 25 |
| Drive systems, rotating loads | 0 | 0 | 1 | 1 | 3 | 5 | 8 | 10 | 13 | 15 | 18 | 20 | 23 | 25 | 25 | 25 | 25 | 25 | 25 | 25 |
| Lighting efficiency | 0 | 0 | 0 | 1 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 11 | 11 | 11 | 11 | 11 | 11 | 11 |
| Interruptible/self–generation | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Direct load control | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Energy management system | 0 | 1 | 2 | 4 | 7 | 14 | 21 | 28 | 35 | 42 | 49 | 56 | 63 | 70 | 70 | 70 | 70 | 70 | 70 | 70 |
| **Subtotal, Industry** | **2** | **4** | **8** | **15** | **30** | **60** | **91** | **121** | **151** | **181** | **211** | **241** | **272** | **302** | **302** | **302** | **302** | **302** | **302** | **302** |
| **Total, Bulgaria** | **3** | **6** | **13** | **26** | **51** | **103** | **154** | **205** | **257** | **308** | **360** | **411** | **462** | **514** | **521** | **529** | **537** | **545** | **553** | **560** |

BSE_GWH.WK1

### 5.2.2.3 Illustrative DSM Program Potential

The illustrative DSM Program Potential estimates the results of a utility-based incentive program designed to overcome the market imperfections, and thereby increase customer acceptance of energy efficiency measures. Despite the provision of incentives and subsidies, utility-sponsored DSM programs may only result in an actual implementation of 25-50% of the technical/economic potential.

Assessing market potential requires actual consumer responses to DSM programs. The survey of Bulgarian industries provides some information on market potential. Without incentives (the current situation), the survey found that 57% of the firms interviewed had not implemented energy efficiency measures, even though three-fourths of the total firms were aware of potential options. The survey found that 76% of those interviewed would be interested in energy efficiency programs, if incentives were offered.

While there are several means of establishing impact and cost-effectiveness, assessing market potential generally requires implementing pilot programs. Pilot programs are the best way to obtain actual customer response to the program offered by the utility.

The analysis of DSM measures, and development of pilot programs needs to consider the percentage of customers (among those who find a particular DSM measure economically attractive) who actually purchase and install that measure. The utility, the government, and DSM companies can undertake marketing programs to affect the level of adoption of DSM measures, and these can be tested in pilot programs. Various changes in intensity, scope, or scale of programmatic and private (e.g., energy service companies) marketing efforts can significantly impact the level of market penetration. Usually, customers may be more likely to adopt a technology if a utility or government agency encourages its use and provides information through an energy-conservation program.

The estimates of the illustrative DSM program potential are shown in Exhibit 5-19. The estimates are based on revisions to the assumptions regarding market penetration for each measure. These assumptions show higher rates of market penetration achieved over a shorter period of time, consistent with experience in the U.S. In summary, we estimate that the illustrative DSM program potential for Bulgaria amounts to about 35% of the technical/economic potential:

> Peak demand reduction of more than 1,000 MW (16% of current maximum load from industrial and buildings sectors)
>
> Energy savings of 2.8 TWh (10% of current consumption by industrial and buildings sectors)

## Exhibit 5–19
## DSM PROGRAM FOR BULGARIA
## ESTIMATED POTENTIAL IMPACT

| Sector | Functional area – Program element | Technical Potential | | DSM Penetration | | DSM Potential | |
|---|---|---|---|---|---|---|---|
| | | Annual Energy Savings GWh | Winter Demand Savings MW | Final Market pct | Time to Final Market yrs | Annual Energy Savings GWh | Winter Demand Savings MW |
| Bldg | Window coverings | 90 | 30 | 50% | 5 | 45 | 15 |
| Bldg | Caulking, weatherstripping | 90 | 30 | 50% | 5 | 45 | 15 |
| Bldg | Thermostat | 180 | 60 | 50% | 5 | 90 | 30 |
| Bldg | Heating – convert from electric to gas | 1,800 | 600 | 10% | 10 | 180 | 60 |
| Bldg | Hot water insulation | 75 | 15 | 50% | 5 | 38 | 8 |
| Bldg | Flow restrictors | 75 | 3 | 50% | 5 | 38 | 2 |
| Bldg | Water heater timer | 75 | 15 | 50% | 5 | 38 | 8 |
| Bldg | Water heater controls | 75 | 15 | 50% | 5 | 38 | 8 |
| Bldg | High efficiency refrigerator | 780 | 93 | 50% | 10 | 390 | 46 |
| Bldg | Fluorescent lighting (residential) | 229 | 43 | 50% | 5 | 114 | 21 |
| Bldg | Fluorescent lighting (commercial) | 450 | 86 | 50% | 5 | 225 | 43 |
| Bldg | Direct load control | 120 | 300 | 25% | 10 | 30 | 75 |
| **Bldg** | **Subtotal** | **3,679** | **1,020** | | | **1,270** | **330** |
| | Savings as pct. of technical potential | | | | | 34.5% | 32.3% |
| | Savings as pct. of current consumption | | | | | 14.8% | 13.8% |
| Indus | Energy/production audit | 1,400 | 400 | 50% | 5 | 700 | 20 |
| Indus | Motor O&M | 252 | 72 | 50% | 5 | 126 | 36 |
| Indus | Compressed Air O&M | 56 | 16 | 50% | 5 | 28 | 8 |
| Indus | High efficiency motors | 252 | 72 | 50% | 5 | 126 | 36 |
| Indus | Drive systems, rotating loads | 252 | 72 | 50% | 5 | 126 | 36 |
| Indus | Lighting efficiency | 105 | 30 | 50% | 5 | 53 | 15 |
| Indus | Interruptible/self–generation | 700 | 1,200 | 10% | 10 | 70 | 120 |
| Indus | Direct load control | 140 | 400 | 20% | 5 | 28 | 80 |
| Indus | Energy management system | 700 | 400 | 50% | 5 | 350 | 200 |
| **Indus** | **Subtotal** | **3,857** | **1,862** | | | **1,607** | **731** |
| | Savings as pct. of technical potential | | | | | 41.7% | 39.3% |
| | Savings as pct. of current consumption | | | | | 8.0% | 18.3% |
| | **Total** | **7,536** | **2,882** | | | **2,876** | **1,061** |
| | Savings as pct. of technical potential | | | | | 38.2% | 36.8% |
| | Savings as pct. of current consumption | | | | | 10.1% | 16.6% |

DSM_DSM.WK1

Note: totals adjusted to account for overlapping

Thus, the estimated net benefit of the DSM program (subtracting the base case energy efficiency improvements that would have happened without a program) are:

> Peak demand reduction of more than 900 MW (15% of current maximum load from industrial and buildings sectors)
>
> Energy savings of 2.2 TWh (9% of current consumption by industrial and buildings sectors)

A new set of energy efficiency supply curves is generated for the illustrative DSM program, using DSM Program Potential GWh/year and costs of conserved energy which include the cost of the illustrative DSM program development, administration, and evaluation. The supply curve of the DSM Program for measures in the buildings sector is shown in Exhibit 5-20. The curve only shows technologies which have a CCE less than the estimated marginal cost of energy supply (about $0.03/kWh). Exhibit 5-21 illustrates the supply curve for the industrial sector.

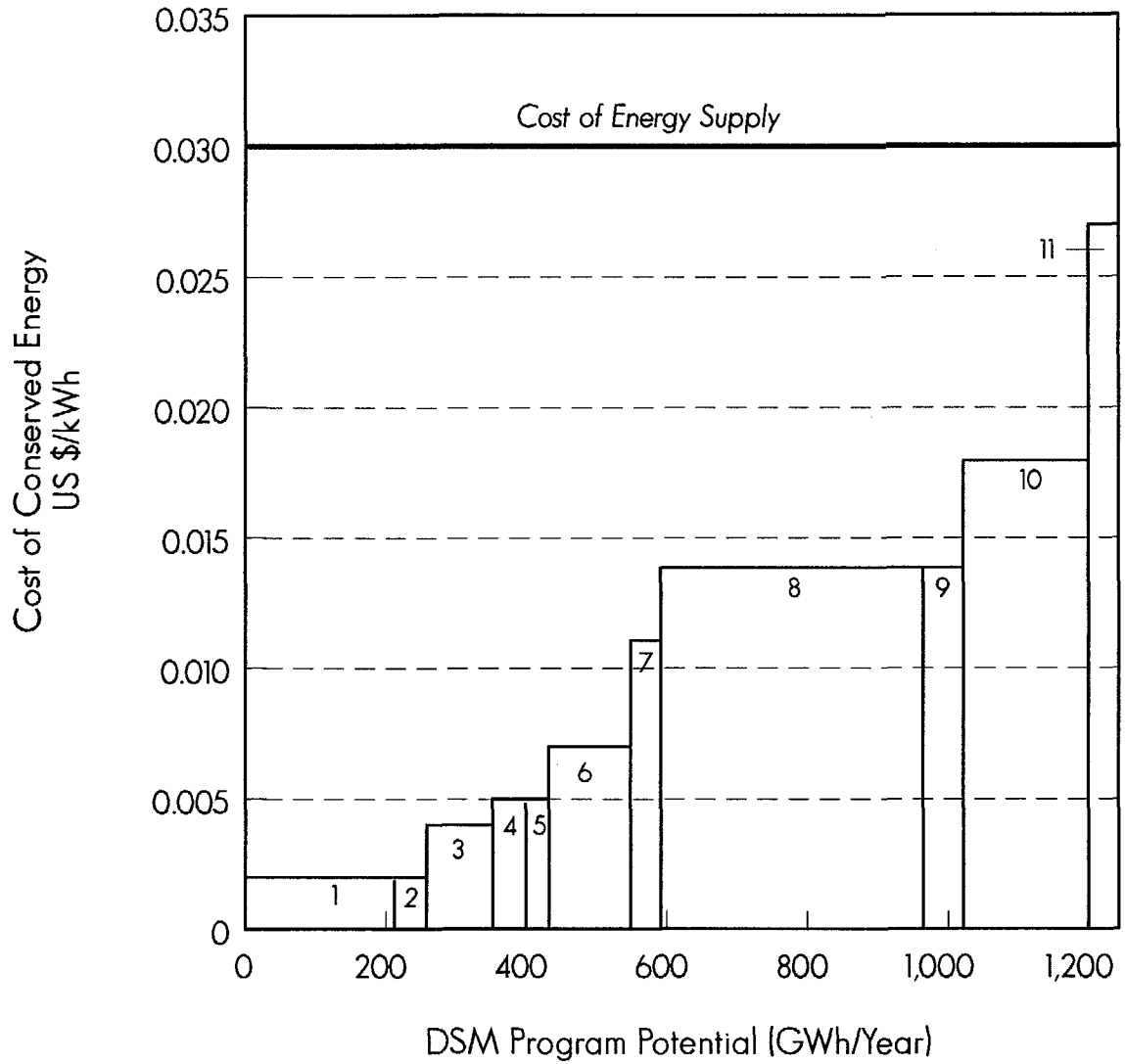
The annual projection of peak demand reduction in the Illustrative DSM Program case is shown in Exhibit 5-22. As indicated, peak demand is reduced by 182 MW in 5 years, 940 MW in 10 years, and 1,061 MW in 20 years.

The annual projection of energy savings in the Illustrative DSM Program case is shown in Exhibit 5-23. The exhibit shows that energy sales are reduced by 508 GWh per year in 5 years, 2,608 GWH per year in 10 years, and 2,876 GWh per year in 20 years.

Exhibit 5-20

**Bulgaria**

**Supply Curve -- Illustrative DSM Program (Buildings Sector)**

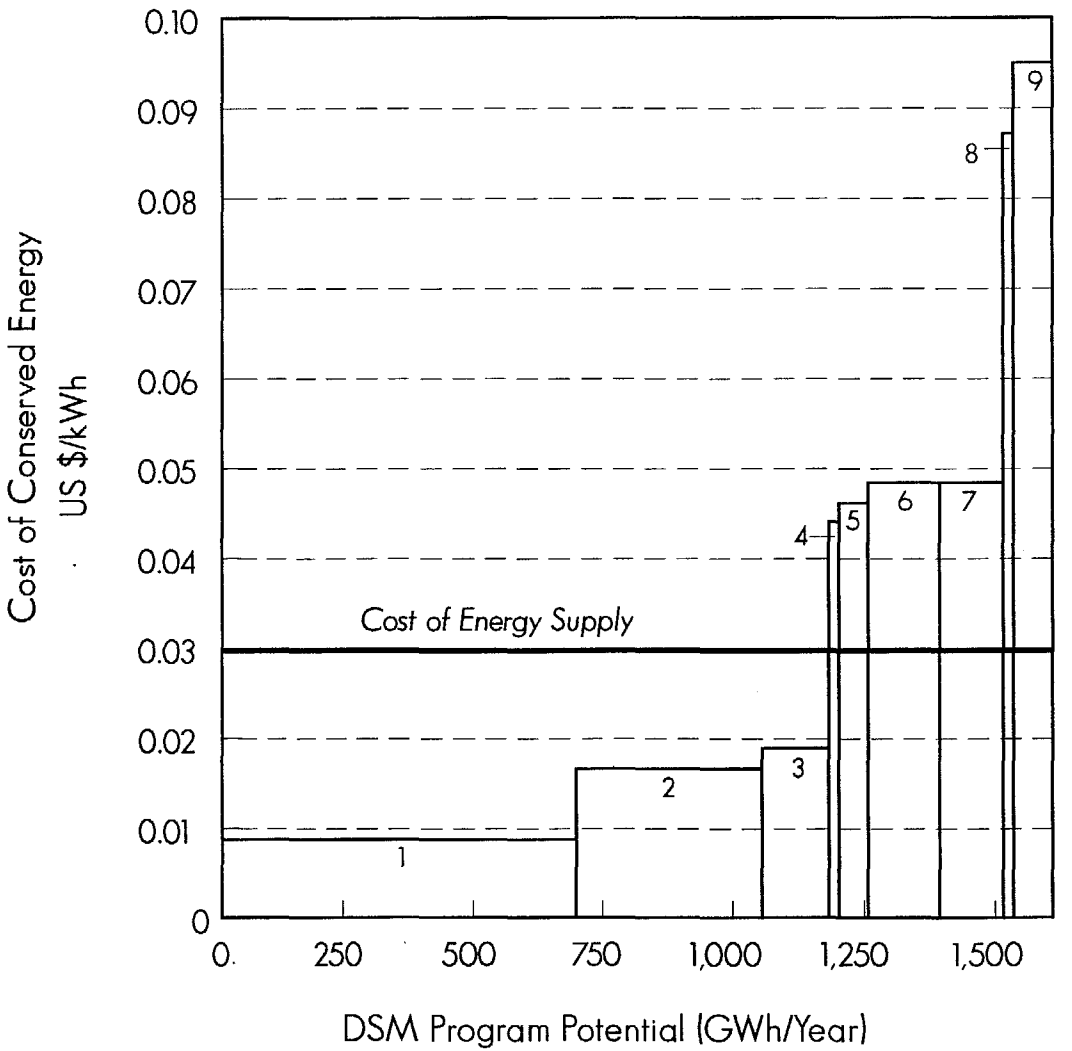



1: Commercial lighting reflectors
2: Water heater controls
3: Thermostats in heating systems
4: Window coverings
5: Water heater timers
6: Residential flourescent lighting
7: Hot water flow restrictors
8: High efficiency refrigerators
9: Caulking, weatherstripping
10: Heating -- convert to gas
11: Hot water insulation

Exhibit 5-21

**Bulgaria**

**Supply Curve -- Illustrative DSM Program (Industry Sector)**




1: Energy/production mgt. audits
2: Computer energy management system
3: Improve motor O&M
4: Improve compressed air O&M
5: Lighting efficiency
6: Drive systems, rotating loads
7: High efficiency motors
8: Direct load control
9: Interruptible/self-generation

**Exhibit 5–22**
**PROJECTION OF MARKET PENETRATION**
**WITH DSM**
**PEAK DEMAND REDUCTION, MW**

| Functional area – Program element | Year 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **BUILDINGS:** | | | | | | | | | | | | | | | | | | | | |
| Window coverings | 0 | 0 | 1 | 2 | 3 | 6 | 9 | 12 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 |
| Caulking, weatherstripping | 0 | 0 | 1 | 2 | 3 | 6 | 9 | 12 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 |
| Thermostat | 0 | 1 | 2 | 3 | 6 | 12 | 18 | 24 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 |
| Heating – convert from electric to gas | 0 | 1 | 2 | 3 | 6 | 12 | 18 | 24 | 30 | 36 | 42 | 48 | 54 | 60 | 60 | 60 | 60 | 60 | 60 | 60 |
| Hot water insulation | 0 | 0 | 0 | 1 | 2 | 3 | 5 | 6 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 |
| Flow restrictors | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| Water heater timer | 0 | 0 | 0 | 1 | 2 | 3 | 5 | 6 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 |
| Water heater controls | 0 | 0 | 0 | 1 | 2 | 3 | 5 | 6 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 |
| High efficiency refrigerator | 0 | 1 | 1 | 2 | 5 | 9 | 14 | 19 | 23 | 28 | 32 | 37 | 42 | 46 | 46 | 46 | 46 | 46 | 46 | 46 |
| Fluorescent lighting (residential) | 0 | 1 | 1 | 2 | 4 | 9 | 13 | 17 | 21 | 21 | 21 | 21 | 21 | 21 | 21 | 21 | 21 | 21 | 21 | 21 |
| Fluorescent lighting (commercial) | 0 | 1 | 2 | 4 | 9 | 17 | 26 | 35 | 43 | 43 | 43 | 43 | 43 | 43 | 43 | 43 | 43 | 43 | 43 | 43 |
| Direct load control | 0 | 1 | 2 | 4 | 8 | 15 | 23 | 30 | 38 | 45 | 53 | 60 | 68 | 75 | 75 | 75 | 75 | 75 | 75 | 75 |
| **Subtotal, Buildings** | **2** | **6** | **12** | **24** | **48** | **96** | **143** | **191** | **239** | **257** | **275** | **294** | **312** | **330** | **330** | **330** | **330** | **330** | **330** | **330** |
| **INDUSTRY:** | | | | | | | | | | | | | | | | | | | | |
| Energy/production audit | 2 | 5 | 10 | 20 | 40 | 80 | 120 | 160 | 200 | 200 | 200 | 200 | 200 | 200 | 200 | 200 | 200 | 200 | 200 | 200 |
| Motor O&M | 0 | 1 | 2 | 4 | 7 | 14 | 22 | 29 | 36 | 36 | 36 | 36 | 36 | 36 | 36 | 36 | 36 | 36 | 36 | 36 |
| Compressed Air O&M | 0 | 0 | 0 | 1 | 2 | 3 | 5 | 6 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 |
| High efficiency motors | 0 | 1 | 2 | 4 | 7 | 14 | 22 | 29 | 36 | 36 | 36 | 36 | 36 | 36 | 36 | 36 | 36 | 36 | 36 | 36 |
| Drive systems, rotating loads | 0 | 1 | 2 | 4 | 7 | 14 | 22 | 29 | 36 | 36 | 36 | 36 | 36 | 36 | 36 | 36 | 36 | 36 | 36 | 36 |
| Lighting efficiency | 0 | 0 | 1 | 2 | 3 | 6 | 9 | 12 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 |
| Interruptible/self–generation | 1 | 1 | 3 | 6 | 12 | 24 | 36 | 48 | 60 | 72 | 84 | 96 | 108 | 120 | 120 | 120 | 120 | 120 | 120 | 120 |
| Direct load control | 1 | 2 | 4 | 8 | 16 | 32 | 48 | 64 | 80 | 80 | 80 | 80 | 80 | 80 | 80 | 80 | 80 | 80 | 80 | 80 |
| Energy management system | 2 | 5 | 10 | 20 | 40 | 80 | 120 | 160 | 200 | 200 | 200 | 200 | 200 | 200 | 200 | 200 | 200 | 200 | 200 | 200 |
| **Subtotal, Industry** | **7** | **16** | **34** | **67** | **134** | **268** | **403** | **537** | **671** | **683** | **695** | **707** | **719** | **731** | **731** | **731** | **731** | **731** | **731** | **731** |
| **Total, Bulgaria** | **9** | **22** | **46** | **91** | **182** | **364** | **546** | **728** | **910** | **940** | **970** | **1,001** | **1,031** | **1,061** | **1,061** | **1,061** | **1,061** | **1,061** | **1,061** | **1,061** |

DSM_MW.WK1

## Exhibit 5–23
## PROJECTION OF MARKET PENETRATION
## WITH DSM
## ENERGY SAVINGS, GWh

| Functional area – Program element | Year 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **BUILDINGS:** | | | | | | | | | | | | | | | | | | | | |
| Window coverings | 0 | 1 | 2 | 5 | 9 | 18 | 27 | 36 | 45 | 45 | 45 | 45 | 45 | 45 | 45 | 45 | 45 | 45 | 45 | 45 |
| Caulking, weatherstripping | 0 | 1 | 2 | 5 | 9 | 18 | 27 | 36 | 45 | 45 | 45 | 45 | 45 | 45 | 45 | 45 | 45 | 45 | 45 | 45 |
| Thermostat | 1 | 2 | 5 | 9 | 18 | 36 | 54 | 72 | 90 | 90 | 90 | 90 | 90 | 90 | 90 | 90 | 90 | 90 | 90 | 90 |
| Heating – convert from electric to gas | 1 | 2 | 5 | 9 | 18 | 36 | 54 | 72 | 90 | 108 | 126 | 144 | 162 | 180 | 180 | 180 | 180 | 180 | 180 | 180 |
| Hot water insulation | 0 | 1 | 2 | 4 | 8 | 15 | 23 | 30 | 38 | 38 | 38 | 38 | 38 | 38 | 38 | 38 | 38 | 38 | 38 | 38 |
| Flow restrictors | 0 | 1 | 2 | 4 | 8 | 15 | 23 | 30 | 38 | 38 | 38 | 38 | 38 | 38 | 38 | 38 | 38 | 38 | 38 | 38 |
| Water heater timer | 0 | 1 | 2 | 4 | 8 | 15 | 23 | 30 | 38 | 38 | 38 | 38 | 38 | 38 | 38 | 38 | 38 | 38 | 38 | 38 |
| Water heater controls | 0 | 1 | 2 | 4 | 8 | 15 | 23 | 30 | 38 | 38 | 38 | 38 | 38 | 38 | 38 | 38 | 38 | 38 | 38 | 38 |
| High efficiency refrigerator | 2 | 5 | 10 | 20 | 39 | 78 | 117 | 156 | 195 | 234 | 273 | 312 | 351 | 390 | 390 | 390 | 390 | 390 | 390 | 390 |
| Fluorescent lighting (residential) | 1 | 3 | 6 | 11 | 23 | 46 | 69 | 92 | 114 | 114 | 114 | 114 | 114 | 114 | 114 | 114 | 114 | 114 | 114 | 114 |
| Fluorescent lighting (commercial) | 2 | 5 | 11 | 23 | 45 | 90 | 135 | 180 | 225 | 225 | 225 | 225 | 225 | 225 | 225 | 225 | 225 | 225 | 225 | 225 |
| Direct load control | 0 | 0 | 1 | 2 | 3 | 6 | 9 | 12 | 15 | 18 | 21 | 24 | 27 | 30 | 30 | 30 | 30 | 30 | 30 | 30 |
| **Subtotal, Buildings** | **10** | **23** | **48** | **97** | **194** | **388** | **582** | **776** | **970** | **1,030** | **1,090** | **1,150** | **1,210** | **1,270** | **1,270** | **1,270** | **1,270** | **1,270** | **1,270** | **1,270** |
| **INDUSTRY:** | | | | | | | | | | | | | | | | | | | | |
| Energy/production audit | 7 | 17 | 35 | 70 | 140 | 280 | 420 | 560 | 700 | 700 | 700 | 700 | 700 | 700 | 700 | 700 | 700 | 700 | 700 | 700 |
| Motor O&M | 1 | 3 | 6 | 13 | 25 | 50 | 76 | 101 | 126 | 126 | 126 | 126 | 126 | 126 | 126 | 126 | 126 | 126 | 126 | 126 |
| Compressed Air O&M | 0 | 1 | 1 | 3 | 6 | 11 | 17 | 22 | 28 | 28 | 28 | 28 | 28 | 28 | 28 | 28 | 28 | 28 | 28 | 28 |
| High efficiency motors | 1 | 3 | 6 | 13 | 25 | 50 | 76 | 101 | 126 | 126 | 126 | 126 | 126 | 126 | 126 | 126 | 126 | 126 | 126 | 126 |
| Drive systems, rotating loads | 1 | 3 | 6 | 13 | 25 | 50 | 76 | 101 | 126 | 126 | 126 | 126 | 126 | 126 | 126 | 126 | 126 | 126 | 126 | 126 |
| Lighting efficiency | 1 | 1 | 3 | 5 | 11 | 21 | 32 | 42 | 53 | 53 | 53 | 53 | 53 | 53 | 53 | 53 | 53 | 53 | 53 | 53 |
| Interruptible/self–generation | 0 | 1 | 2 | 4 | 7 | 14 | 21 | 28 | 35 | 42 | 49 | 56 | 63 | 70 | 70 | 70 | 70 | 70 | 70 | 70 |
| Direct load control | 0 | 1 | 1 | 3 | 6 | 11 | 17 | 22 | 28 | 28 | 28 | 28 | 28 | 28 | 28 | 28 | 28 | 28 | 28 | 28 |
| Energy management system | 4 | 8 | 18 | 35 | 70 | 140 | 210 | 280 | 350 | 350 | 350 | 350 | 350 | 350 | 350 | 350 | 350 | 350 | 350 | 350 |
| **Subtotal, Industry** | **16** | **38** | **79** | **157** | **314** | **629** | **943** | **1,257** | **1,572** | **1,579** | **1,586** | **1,593** | **1,600** | **1,607** | **1,607** | **1,607** | **1,607** | **1,607** | **1,607** | **1,607** |
| **Total, Bulgaria** | **25** | **61** | **127** | **254** | **508** | **1,016** | **1,525** | **2,033** | **2,541** | **2,608** | **2,675** | **2,742** | **2,809** | **2,876** | **2,876** | **2,876** | **2,876** | **2,876** | **2,876** | **2,876** |

DSM_GWH.WK1

### 5.2.3 Projections of Economic Costs

Based on the market penetration rates described above, annual projections of economic costs were developed. These are the total costs of implementing the measures, whether paid fully by the customer (as is assumed in the base case) or paid through a partnership between the customer and the electric utility (as is assumed in the DSM case).

#### 5.2.3.1 Costs Under the Base Case (Market Forces)

The annual economic costs of energy efficiency improvements under the base case are indicated in Exhibit 5-24. Even under the base case, significant investments in energy efficiency are expected to occur, e.g. $6.5 million per year in years 6 though 14.

#### 5.2.3.2 Costs Under the Illustrative DSM Program

The annual economic costs of energy efficiency improvements under Illustrative DSM Program are indicated in Exhibit 5-25. Much greater investments are required, peaking at $76 million per year once the program gets fully under way:

| | |
|---|---|
| Year 1: | $4 million |
| Year 2: | $5 million |
| Year 3: | $10 million |
| Year 4: | $19 million |
| Year 5: | $38 million |
| Years 6 - 9: | $76 million per year |

### 5.2.4 Economic Analysis of the Illustrative DSM Program

The investments required for the Illustrative DSM Program are large, especially considering the ability of the Bulgarian economy to finance investment at this time. An economic analysis is required to determine if these costs could be justified.

Exhibit 5-26 shows a summary projection of the annual costs and benefits for the base case and the Illustrative DSM program. The programs achieve break-even by the end of the seventh year.

## Exhibit 5–24
## PROJECTION OF ECONOMIC COST
## BASE CASE – NO DSM

| Functional area – Program element | Thousands of US Dollars per Year | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |
| **BUILDINGS:** | | | | | | | | | | | | | | | | | | | | |
| Window coverings | 2 | 2 | 4 | 8 | 17 | 33 | 33 | 33 | 33 | 33 | 33 | 33 | 33 | 33 | 0 | 0 | 0 | 0 | 0 | 0 |
| Caulking, weatherstripping | 5 | 7 | 14 | 26 | 52 | 104 | 104 | 104 | 104 | 104 | 104 | 104 | 104 | 104 | 0 | 0 | 0 | 0 | 0 | 0 |
| Thermostat | 3 | 4 | 8 | 15 | 30 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 0 | 0 | 0 | 0 | 0 | 0 |
| Heating – convert from electric to gas | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Hot water insulation | 8 | 12 | 22 | 42 | 84 | 168 | 168 | 168 | 168 | 168 | 168 | 168 | 168 | 168 | 0 | 0 | 0 | 0 | 0 | 0 |
| Flow restrictors | 3 | 5 | 9 | 17 | 34 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 0 | 0 | 0 | 0 | 0 | 0 |
| Water heater timer | 2 | 2 | 4 | 8 | 15 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 0 | 0 | 0 | 0 | 0 | 0 |
| Water heater controls | 1 | 1 | 2 | 4 | 8 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 0 | 0 | 0 | 0 | 0 | 0 |
| High efficiency refrigerator | 41 | 57 | 107 | 205 | 410 | 820 | 820 | 820 | 820 | 820 | 820 | 820 | 820 | 820 | 820 | 820 | 820 | 820 | 820 | 820 |
| Incandescent to fluorescent | 7 | 10 | 18 | 35 | 69 | 138 | 138 | 138 | 138 | 138 | 138 | 138 | 138 | 138 | 0 | 0 | 0 | 0 | 0 | 0 |
| Other lighting upgrades | 4 | 6 | 11 | 21 | 42 | 84 | 84 | 84 | 84 | 84 | 84 | 84 | 84 | 84 | 0 | 0 | 0 | 0 | 0 | 0 |
| Direct load control | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Subtotal, Buildings** | **76** | **106** | **198** | **380** | **760** | **1,521** | **1,521** | **1,521** | **1,521** | **1,521** | **1,521** | **1,521** | **1,521** | **1,521** | **820** | **820** | **820** | **820** | **820** | **820** |
| **INDUSTRY:** | | | | | | | | | | | | | | | | | | | | |
| Energy/production audit | 50 | 70 | 130 | 250 | 500 | 1,000 | 1,000 | 1,000 | 1,000 | 1,000 | 1,000 | 1,000 | 1,000 | 1,000 | 0 | 0 | 0 | 0 | 0 | 0 |
| Motor O&M | 20 | 28 | 52 | 100 | 200 | 400 | 400 | 400 | 400 | 400 | 400 | 400 | 400 | 400 | 0 | 0 | 0 | 0 | 0 | 0 |
| Compressed Air O&M | 10 | 14 | 26 | 50 | 100 | 200 | 200 | 200 | 200 | 200 | 200 | 200 | 200 | 200 | 0 | 0 | 0 | 0 | 0 | 0 |
| High efficiency motors | 50 | 70 | 130 | 250 | 500 | 1,000 | 1,000 | 1,000 | 1,000 | 1,000 | 1,000 | 1,000 | 1,000 | 1,000 | 0 | 0 | 0 | 0 | 0 | 0 |
| Drive systems, rotating loads | 50 | 70 | 130 | 250 | 500 | 1,000 | 1,000 | 1,000 | 1,000 | 1,000 | 1,000 | 1,000 | 1,000 | 1,000 | 0 | 0 | 0 | 0 | 0 | 0 |
| Lighting efficiency | 20 | 28 | 52 | 100 | 200 | 400 | 400 | 400 | 400 | 400 | 400 | 400 | 400 | 400 | 0 | 0 | 0 | 0 | 0 | 0 |
| Interruptible/self–generation | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Direct load control | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Energy management system | 50 | 70 | 130 | 250 | 500 | 1,000 | 1,000 | 1,000 | 1,000 | 1,000 | 1,000 | 1,000 | 1,000 | 1,000 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Subtotal, Industry** | **250** | **350** | **650** | **1,250** | **2,500** | **5,000** | **5,000** | **5,000** | **5,000** | **5,000** | **5,000** | **5,000** | **5,000** | **5,000** | **0** | **0** | **0** | **0** | **0** | **0** |
| **Total, Bulgaria** | **326** | **456** | **848** | **1,630** | **3,260** | **6,521** | **6,521** | **6,521** | **6,521** | **6,521** | **6,521** | **6,521** | **6,521** | **6,521** | **820** | **820** | **820** | **820** | **820** | **820** |

BSE_COST.WK1

## Exhibit 5–25
## PROJECTION OF ECONOMIC COST
## WITH DSM

| Functional area – Program element | Thousands of US Dollars per Year | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |
| **BUILDINGS:** | | | | | | | | | | | | | | | | | | | | |
| Window coverings | 17 | 23 | 43 | 83 | 167 | 333 | 333 | 333 | 333 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Caulking, weatherstripping | 52 | 73 | 135 | 260 | 521 | 1,042 | 1,042 | 1,042 | 1,042 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Thermostat | 30 | 42 | 78 | 150 | 300 | 600 | 600 | 600 | 600 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Heating – convert from electric to gas | 121 | 169 | 314 | 603 | 1,206 | 2,412 | 2,412 | 2,412 | 2,412 | 2,412 | 2,412 | 2,412 | 2,412 | 2,412 | 0 | 0 | 0 | 0 | 0 | 0 |
| Hot water insulation | 84 | 118 | 218 | 420 | 840 | 1,680 | 1,680 | 1,680 | 1,680 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Flow restrictors | 34 | 47 | 87 | 168 | 336 | 672 | 672 | 672 | 672 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Water heater timer | 15 | 21 | 39 | 75 | 150 | 300 | 300 | 300 | 300 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Water heater controls | 8 | 11 | 20 | 38 | 77 | 153 | 153 | 153 | 153 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| High efficiency refrigerator | 205 | 287 | 533 | 1,025 | 2,051 | 4,102 | 4,102 | 4,102 | 4,102 | 4,102 | 4,102 | 4,102 | 4,102 | 4,102 | 0 | 0 | 0 | 0 | 0 | 0 |
| Fluorescent lighting (residential) | 69 | 97 | 180 | 345 | 691 | 1,382 | 1,382 | 1,382 | 1,382 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Fluorescent lighting (commercial) | 42 | 59 | 109 | 211 | 421 | 842 | 842 | 842 | 842 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Direct load control | 188 | 263 | 488 | 938 | 1,875 | 3,750 | 3,750 | 3,750 | 3,750 | 3,750 | 3,750 | 3,750 | 3,750 | 3,750 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Subtotal, Buildings** | **863** | **1,209** | **2,245** | **4,317** | **8,634** | **17,267** | **17,267** | **17,267** | **17,267** | **10,264** | **10,264** | **10,264** | **10,264** | **10,264** | **0** | **0** | **0** | **0** | **0** | **0** |
| **INDUSTRY:** | | | | | | | | | | | | | | | | | | | | |
| Energy/production audit | 500 | 700 | 1,300 | 2,500 | 5,000 | 10,000 | 10,000 | 10,000 | 10,000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Motor O&M | 200 | 280 | 520 | 1,000 | 2,000 | 4,000 | 4,000 | 4,000 | 4,000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Compressed Air O&M | 100 | 140 | 260 | 500 | 1,000 | 2,000 | 2,000 | 2,000 | 2,000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| High efficiency motors | 500 | 700 | 1,300 | 2,500 | 5,000 | 10,000 | 10,000 | 10,000 | 10,000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Drive systems, rotating loads | 500 | 700 | 1,300 | 2,500 | 5,000 | 10,000 | 10,000 | 10,000 | 10,000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Lighting efficiency | 200 | 280 | 520 | 1,000 | 2,000 | 4,000 | 4,000 | 4,000 | 4,000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Interruptible/self–generation | 250 | 350 | 650 | 1,250 | 2,500 | 5,000 | 5,000 | 5,000 | 5,000 | 5,000 | 5,000 | 5,000 | 5,000 | 5,000 | 0 | 0 | 0 | 0 | 0 | 0 |
| Direct load control | 200 | 280 | 520 | 1,000 | 2,000 | 4,000 | 4,000 | 4,000 | 4,000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Energy management system | 500 | 700 | 1,300 | 2,500 | 5,000 | 10,000 | 10,000 | 10,000 | 10,000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Subtotal, Industry** | **2,950** | **4,130** | **7,670** | **14,750** | **29,500** | **59,000** | **59,000** | **59,000** | **59,000** | **5,000** | **5,000** | **5,000** | **5,000** | **5,000** | **0** | **0** | **0** | **0** | **0** | **0** |
| **Total, Bulgaria** | **3,813** | **5,339** | **9,915** | **19,067** | **38,134** | **76,267** | **76,267** | **76,267** | **76,267** | **15,264** | **15,264** | **15,264** | **15,264** | **15,264** | **0** | **0** | **0** | **0** | **0** | **0** |

DSM_COST.WK1

## Exhibit 5–26
## BULGARIA
## SUMMARY OF DSM PROGRAM COSTS AND BENEFITS

| | Millions of US Dollars per Year | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |
| **1. Base case – No DSM program** | | | | | | | | | | | | | | | | | | | | |
| **Buildings:** | | | | | | | | | | | | | | | | | | | | |
| Achieved GWh savings | 1 | 3 | 5 | 11 | 21 | 42 | 64 | 85 | 106 | 127 | 148 | 170 | 191 | 212 | 220 | 228 | 235 | 243 | 251 | 259 |
| Achieved MW savings | 0 | 0 | 1 | 2 | 4 | 8 | 12 | 16 | 19 | 23 | 27 | 31 | 35 | 39 | 40 | 41 | 42 | 43 | 44 | 45 |
| Investment cost ($million) | 0.08 | 0.11 | 0.20 | 0.38 | 0.76 | 1.52 | 1.52 | 1.52 | 1.52 | 1.52 | 1.52 | 1.52 | 1.52 | 1.52 | 0.82 | 0.82 | 0.82 | 0.82 | 0.82 | 0.82 |
| Economic benefits ($million) | 0.04 | 0.10 | 0.21 | 0.43 | 0.85 | 1.70 | 2.55 | 3.40 | 4.25 | 5.10 | 5.95 | 6.80 | 7.65 | 8.50 | 8.79 | 9.07 | 9.36 | 9.64 | 9.93 | 10.21 |
| Net benefits ($million) | −0.03 | 0.00 | 0.01 | 0.04 | 0.09 | 0.18 | 1.03 | 1.88 | 2.73 | 3.58 | 4.43 | 5.28 | 6.13 | 6.98 | 7.97 | 8.25 | 8.54 | 8.82 | 9.11 | 9.39 |
| **Industry:** | | | | | | | | | | | | | | | | | | | | |
| Achieved GWh savings | 2 | 4 | 8 | 15 | 30 | 60 | 91 | 121 | 151 | 181 | 211 | 241 | 272 | 302 | 302 | 302 | 302 | 302 | 302 | 302 |
| Achieved MW savings | 1 | 1 | 3 | 5 | 11 | 21 | 32 | 42 | 53 | 64 | 74 | 85 | 96 | 106 | 106 | 106 | 106 | 106 | 106 | 106 |
| Investment cost ($million) | 0.25 | 0.35 | 0.65 | 1.25 | 2.50 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Economic benefits ($million) | 0.07 | 0.18 | 0.37 | 0.74 | 1.49 | 2.98 | 4.47 | 5.96 | 7.45 | 8.94 | 10.42 | 11.91 | 13.40 | 14.89 | 14.89 | 14.89 | 14.89 | 14.89 | 14.89 | 14.89 |
| Net benefits ($million) | −0.18 | −0.17 | −0.28 | −0.51 | −1.01 | −2.02 | −0.53 | 0.96 | 2.45 | 3.94 | 5.42 | 6.91 | 8.40 | 9.89 | 14.89 | 14.89 | 14.89 | 14.89 | 14.89 | 14.89 |
| **Total** | | | | | | | | | | | | | | | | | | | | |
| Achieved GWh savings | 3 | 6 | 13 | 26 | 51 | 103 | 154 | 205 | 257 | 308 | 360 | 411 | 462 | 514 | 521 | 529 | 537 | 545 | 553 | 560 |
| Achieved MW savings | 1 | 2 | 4 | 7 | 15 | 29 | 44 | 58 | 73 | 87 | 102 | 116 | 131 | 145 | 146 | 147 | 148 | 149 | 150 | 151 |
| Investment cost ($million) | 0.33 | 0.46 | 0.85 | 1.63 | 3.26 | 6.52 | 6.52 | 6.52 | 6.52 | 6.52 | 6.52 | 6.52 | 6.52 | 6.52 | 0.82 | 0.82 | 0.82 | 0.82 | 0.82 | 0.82 |
| Economic benefits ($million) | 0.12 | 0.28 | 0.58 | 1.17 | 2.34 | 4.68 | 7.02 | 9.36 | 11.70 | 14.04 | 16.37 | 18.71 | 21.05 | 23.39 | 23.68 | 23.96 | 24.25 | 24.53 | 24.82 | 25.10 |
| Net benefits ($million) | −0.21 | −0.18 | −0.26 | −0.46 | −0.92 | −1.84 | 0.50 | 2.84 | 5.18 | 7.51 | 9.85 | 12.19 | 14.53 | 16.87 | 22.86 | 23.14 | 23.43 | 23.71 | 24.00 | 24.28 |
| **2. Recommended DSM program** | | | | | | | | | | | | | | | | | | | | |
| **Buildings:** | | | | | | | | | | | | | | | | | | | | |
| Achieved GWh savings | 10 | 23 | 48 | 97 | 194 | 388 | 582 | 776 | 970 | 1,030 | 1,090 | 1,150 | 1,210 | 1,270 | 1,270 | 1,270 | 1,270 | 1,270 | 1,270 | 1,270 |
| Achieved MW savings | 2 | 6 | 12 | 24 | 48 | 96 | 143 | 191 | 239 | 257 | 275 | 294 | 312 | 330 | 330 | 330 | 330 | 330 | 330 | 330 |
| Investment cost ($million) | 0.86 | 1.21 | 2.24 | 4.32 | 8.63 | 17.27 | 17.27 | 17.27 | 17.27 | 10.26 | 10.26 | 10.26 | 10.26 | 10.26 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Economic benefits ($million) | 0.42 | 1.01 | 2.11 | 4.22 | 8.45 | 16.90 | 25.34 | 33.79 | 42.24 | 45.04 | 47.83 | 50.63 | 53.43 | 56.23 | 56.23 | 56.23 | 56.23 | 56.23 | 56.23 | 56.23 |
| Net benefits ($million) | −0.44 | −0.19 | −0.13 | −0.09 | −0.19 | −0.37 | 8.08 | 16.52 | 24.97 | 34.77 | 37.57 | 40.37 | 43.17 | 45.96 | 56.23 | 56.23 | 56.23 | 56.23 | 56.23 | 56.23 |
| **Industry:** | | | | | | | | | | | | | | | | | | | | |
| Achieved GWh savings | 16 | 38 | 79 | 157 | 314 | 629 | 943 | 1,257 | 1,572 | 1,579 | 1,586 | 1,593 | 1,600 | 1,607 | 1,607 | 1,607 | 1,607 | 1,607 | 1,607 | 1,607 |
| Achieved MW savings | 7 | 16 | 34 | 67 | 134 | 268 | 403 | 537 | 671 | 683 | 695 | 707 | 719 | 731 | 731 | 731 | 731 | 731 | 731 | 731 |
| Investment cost ($million) | 2.95 | 4.13 | 7.67 | 14.75 | 29.50 | 59.00 | 59.00 | 59.00 | 59.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Economic benefits ($million) | 0.84 | 2.02 | 4.20 | 8.41 | 16.81 | 33.62 | 50.43 | 67.24 | 84.05 | 84.92 | 85.79 | 86.66 | 87.53 | 88.40 | 88.40 | 88.40 | 88.40 | 88.40 | 88.40 | 88.40 |
| Net benefits ($million) | −2.11 | −2.11 | −3.47 | −6.35 | −12.69 | −25.38 | −8.57 | 8.24 | 25.05 | 79.92 | 80.79 | 81.66 | 82.53 | 83.40 | 88.40 | 88.40 | 88.40 | 88.40 | 88.40 | 88.40 |
| **Total** | | | | | | | | | | | | | | | | | | | | |
| Achieved GWh savings | 25 | 61 | 127 | 254 | 508 | 1,016 | 1,525 | 2,033 | 2,541 | 2,608 | 2,675 | 2,742 | 2,809 | 2,876 | 2,876 | 2,876 | 2,876 | 2,876 | 2,876 | 2,876 |
| Achieved MW savings | 9 | 22 | 46 | 91 | 182 | 364 | 546 | 728 | 910 | 940 | 970 | 1,001 | 1,031 | 1,061 | 1,061 | 1,061 | 1,061 | 1,061 | 1,061 | 1,061 |
| Investment cost ($million) | 3.81 | 5.34 | 9.91 | 19.07 | 38.13 | 76.27 | 76.27 | 76.27 | 76.27 | 15.26 | 15.26 | 15.26 | 15.26 | 15.26 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Economic benefits ($million) | 1.26 | 3.03 | 6.31 | 12.63 | 25.26 | 50.52 | 75.77 | 101.03 | 126.29 | 129.96 | 133.62 | 137.29 | 140.96 | 144.63 | 144.63 | 144.63 | 144.63 | 144.63 | 144.63 | 144.63 |
| Net benefits ($million) | −2.55 | −2.31 | −3.60 | −6.44 | −12.88 | −25.75 | −0.49 | 24.76 | 50.02 | 114.69 | 118.36 | 122.03 | 125.70 | 129.36 | 144.63 | 144.63 | 144.63 | 144.63 | 144.63 | 144.63 |

SUM_ECON.WK1

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Exhibit 5-27 shows a summary projection of the annual net effect (net costs and benefits) of the Illustrative DSM program, and the resulting economic analysis. Based on the annual net benefits (benefits minus costs), an economic analysis is carried out using discounted cashflow techniques. Using a discount rate of 10% and a 20-year investment planning horizon, the following economic evaluation results:

Net Present Value (NPV):

| | |
|---|---|
| DSM in buildings | $129 million |
| DSM in industry | $183 million |
| Total Illustrative DSM Program | $312 million |

Benefit/Cost Ratio (discounted, also known as total resource cost, TRC):

| | |
|---|---|
| DSM in buildings | 3.35 |
| DSM in industry | 2.28 |
| Total Illustrative DSM Program | 2.58 |

Internal rate of return (IRR):

| | |
|---|---|
| DSM in buildings | 92% |
| DSM in industry | 38% |
| Total Illustrative DSM Program | 48% |

Another evaluation is the cost of conserved energy (CCE). In this calculation, the NPV of the annual cost stream is divided by the NPV of the annual energy savings stream to obtain an estimate in $/kWh. This calculation is somewhat distorted, since it puts all costs against energy, giving no recognition to peak demand reduction. However, it does give a direct basis for comparison against the marginal cost of energy supply, which we calculated as about $0.03/kWh. The CCE for the Illustrative DSM Program is significantly lower than supply-side energy, calculated as:

| | |
|---|---|
| DSM in buildings | $0.013/kWh |
| DSM in industry | $0.024/kWh |
| Total Illustrative DSM Program | $0.020/kWh |

The values of IRR are well above the common values of minimum acceptable rate of return (hurdle rates) used in project evaluation by the World Bank, EBRD, or other lenders. The cost of the energy conserved is only a little more than half the marginal cost of energy supply. The other economic evaluation criteria all show very positive results, and thus we conclude that the Illustrative DSM program is a very attractive investment for Bulgaria.

## Exhibit 5–27
## BULGARIA
## SUMMARY OF DSM PROGRAM ECONOMIC ANALYSIS

| | Millions of US Dollars per Year | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |
| **1. Summary – net effect of DSM program** | | | | | | | | | | | | | | | | | | | | |
| **Buildings:** | | | | | | | | | | | | | | | | | | | | |
| Net achieved GWh savings | 9 | 21 | 43 | 86 | 173 | 345 | 518 | 691 | 864 | 902 | 941 | 980 | 1,019 | 1,058 | 1,050 | 1,042 | 1,034 | 1,026 | 1,019 | 1,011 |
| Net achieved MW savings | 2 | 5 | 11 | 22 | 44 | 88 | 132 | 176 | 220 | 234 | 248 | 262 | 277 | 291 | 290 | 289 | 288 | 287 | 286 | 285 |
| Incremental investment cost ($million) | 0.79 | 1.10 | 2.05 | 3.94 | 7.87 | 15.75 | 15.75 | 15.75 | 15.75 | 8.74 | 8.74 | 8.74 | 8.74 | 8.74 | −0.82 | −0.82 | −0.82 | −0.82 | −0.82 | −0.82 |
| Incremental economic benefits ($million) | 0.38 | 0.91 | 1.90 | 3.80 | 7.60 | 15.20 | 22.79 | 30.39 | 37.99 | 39.94 | 41.88 | 43.83 | 45.78 | 47.73 | 47.44 | 47.16 | 46.87 | 46.59 | 46.30 | 46.02 |
| Net benefits ($million) | −0.41 | −0.19 | −0.15 | −0.14 | −0.28 | −0.55 | 7.05 | 14.64 | 22.24 | 31.19 | 33.14 | 35.09 | 37.04 | 38.98 | 48.26 | 47.98 | 47.69 | 47.41 | 47.12 | 46.84 |
| Net present value ($million) | 129 | | | | | | | | | | | | | | | | | | | |
| Internal rate of return | 92.1% | | | | | | | | | | | | | | | | | | | |
| Benefit/cost ratio | 3.35 | | | | | | | | | | | | | | | | | | | |
| Cost of conserved energy ($/kWh) | 0.013 | | | | | | | | | | | | | | | | | | | |
| **Industry:** | | | | | | | | | | | | | | | | | | | | |
| Net achieved GWh savings | 14 | 34 | 71 | 142 | 284 | 568 | 852 | 1,137 | 1,421 | 1,397 | 1,374 | 1,351 | 1,328 | 1,305 | 1,305 | 1,305 | 1,305 | 1,305 | 1,305 | 1,305 |
| Net achieved MW savings | 6 | 15 | 31 | 62 | 124 | 247 | 371 | 494 | 618 | 619 | 621 | 622 | 623 | 625 | 625 | 625 | 625 | 625 | 625 | 625 |
| Incremental investment cost ($million) | 2.70 | 3.78 | 7.02 | 13.50 | 27.00 | 54.00 | 54.00 | 54.00 | 54.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Incremental economic benefits ($million) | 0.77 | 1.84 | 3.83 | 7.66 | 15.32 | 30.64 | 45.96 | 61.28 | 76.60 | 75.98 | 75.37 | 74.75 | 74.13 | 73.51 | 73.51 | 73.51 | 73.51 | 73.51 | 73.51 | 73.51 |
| Net benefits ($million) | −1.93 | −1.94 | −3.19 | −5.84 | −11.68 | −23.36 | −8.04 | 7.28 | 22.60 | 75.98 | 75.37 | 74.75 | 74.13 | 73.51 | 73.51 | 73.51 | 73.51 | 73.51 | 73.51 | 73.51 |
| Net present value ($million) | 183 | | | | | | | | | | | | | | | | | | | |
| Internal rate of return | 38.8% | | | | | | | | | | | | | | | | | | | |
| Benefit/cost ratio | 2.28 | | | | | | | | | | | | | | | | | | | |
| Cost of conserved energy ($/kWh) | 0.024 | | | | | | | | | | | | | | | | | | | |
| **Total** | | | | | | | | | | | | | | | | | | | | |
| Net achieved GWh savings | 23 | 55 | 114 | 228 | 457 | 914 | 1,371 | 1,827 | 2,284 | 2,300 | 2,316 | 2,331 | 2,347 | 2,362 | 2,355 | 2,347 | 2,339 | 2,331 | 2,323 | 2,316 |
| Net achieved MW savings | 8 | 20 | 42 | 84 | 168 | 335 | 503 | 670 | 838 | 853 | 869 | 884 | 900 | 916 | 915 | 914 | 913 | 912 | 911 | 910 |
| Incremental investment cost ($million) | 3.49 | 4.88 | 9.07 | 17.44 | 34.87 | 69.75 | 69.75 | 69.75 | 69.75 | 8.74 | 8.74 | 8.74 | 8.74 | 8.74 | −0.82 | −0.82 | −0.82 | −0.82 | −0.82 | −0.82 |
| Incremental economic benefits ($million) | 1.15 | 2.75 | 5.73 | 11.46 | 22.92 | 45.84 | 68.76 | 91.67 | 114.59 | 115.92 | 117.25 | 118.58 | 119.91 | 121.24 | 120.95 | 120.67 | 120.38 | 120.09 | 119.81 | 119.52 |
| Net benefits ($million) | −2.34 | −2.13 | −3.34 | −5.98 | −11.95 | −23.91 | −0.99 | 21.93 | 44.85 | 107.18 | 108.51 | 109.84 | 111.16 | 112.49 | 121.77 | 121.49 | 121.20 | 120.92 | 120.63 | 120.35 |
| Net present value ($million) | 312 | | | | | | | | | | | | | | | | | | | |
| Internal rate of return | 48% | | | | | | | | | | | | | | | | | | | |
| Benefit/cost ratio | 2.58 | | | | | | | | | | | | | | | | | | | |
| Cost of conserved energy ($/kWh) | 0.020 | | | | | | | | | | | | | | | | | | | |

EXHB5–27.WK1

### 5.2.5 Effect of the Illustrative DSM Program on the Demand Forecast

Finally, the net effect of the Illustrative DSM Program was incorporated into the demand forecast, so that annual energy requirements can be seen.

Exhibit 5-28 shows the effect on energy demand. A net benefit of nearly 2 TWh/year is achieved by year 2005.

## 5.3 ACTION PLAN TO LAUNCH A DSM PROGRAM IN BULGARIA

Implementing DSM appears to be part of a least-cost power sector investment program for Bulgaria. Initiating activities in DSM will require a demonstration project, in order to establish the local context in which DSM technologies, policies, financing mechanisms can succeed.

The Illustrative DSM Program described in this report is based on preliminary data, which is very limited. This limited data is insufficient to fully evaluate the very large investments required.

However, the preliminary analysis in this report serves as a basis for identifying the next steps to implementing the program. These activities should be pursued in parallel to achieve early success. The key actions for the next 1-2 years are summarized below.

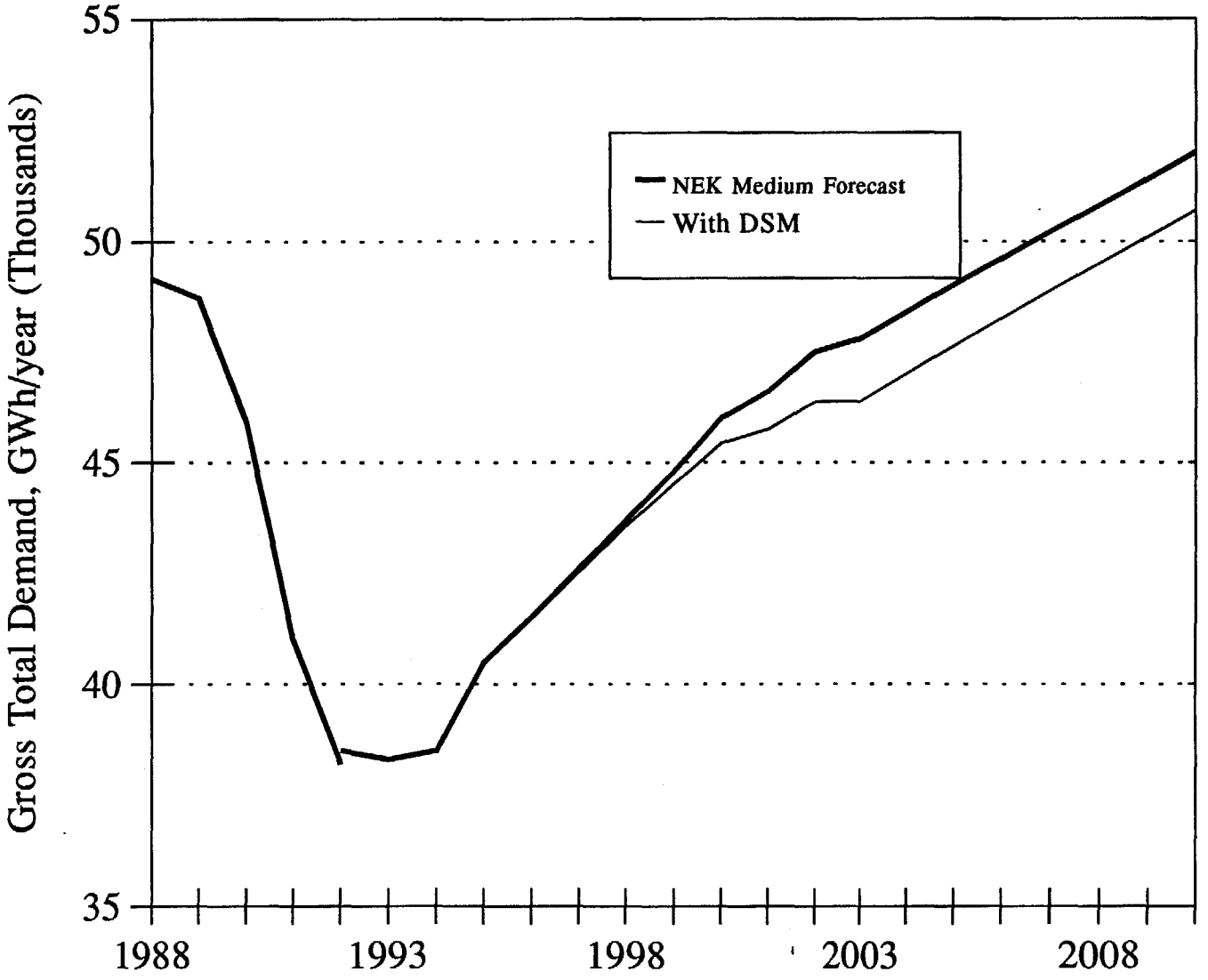
- **Develop and Implement Pilot DSM Programs:** To gain more experience and collect data in Bulgaria, pilot DSM programs for the buildings and industrial sectors should be designed and implemented at one or more distribution branches of NEK. One of the key tasks is the development of the level of incentives or other expenditures to be made by NEK for the program, and the method by which NEK will recover revenues lost by the energy savings. Developing pilot DSM programs also involves a number of tasks to resolve issues such as market research, program design, selection of technical measures, screening of applications, financing options, implementation by private sector firms, collection of payments by NEK, independent evaluation, and program redesign.

- **Institutional Development**: A parallel step is needed to develop laws and regulations necessary to implement utility Integrated Resource Planning. Within the IRP framework, regulations next need to be put in place to ensure that development of the DSM potential proceeds at the optimum rate. Further, COE and NEK should establish departments responsible for IRP, DSM, and customer service.

Exhibit 5-28

# Bulgaria - Total Electricity Demand

Effect of Illustrative DSM Program



- **Load Research and DSM Assessment:** The customer service department at NEK would be assigned to carry out load research, to collect data on energy usage by customers. This project will measure the dynamics of specific loads and then combine these data with statistical and building simulation models to evaluate DSM potential. These additional data should be used to perform a detailed DSM cost-benefit assessment.

## 5.3.1 Develop and Implement Pilot DSM Programs

### 5.3.1.1 Introduction

Pilot DSM programs are necessary to determine which technologies and procedures are best suited to Bulgaria. The actions to be taken to develop the pilot programs can be divided into a number of steps, which are listed below and then discussed:

- NEK expenditures and recovery of lost revenues
- Research
- Program Design
- Implementation of Pilot
- Evaluation and Redesign
- Preparation for Full-Scale Development

For DSM to succeed, it is necessary that the Bulgarian electric utilities be given the proper financial incentive, so that their decisions are able to mirror what is best for the country. The recommended incentives for the pilot program are:

- allow DSM capital investments by NEK to earn a rate of return which is high enough to encourage NEK to make the investment;

- allow other (non-capital) DSM expenses incurred by NEK to be recovered through tariffs in the same year they are incurred;

- provide NEK employee incentives based on services and efficiency, rather than energy sales.

One or more NEK distribution branches should be selected for the DSM pilot program. These branches should be representative of industrial and buildings customer load profiles.

Market research of customers would be performed to determine the market segments and target the appropriate markets. A marketing strategy for each program would also be identified. This might mean working with utility personnel and "trade allies," (equipment manufacturers, dealers, builders, electricians, architects, etc. involved in building,

specifying, or buying equipment and buildings). One of the most important aspects of the research is to determine the appropriate incentive level to be provided in a program. Except for the low-income program, the customer receiving the measure should pay a portion of the costs. The relative share between the customer and the utility must be determined.

Program design includes developing the application form, developing the database tracking system, preparing the marketing plan, developing a quality assurance plan, scoping out the evaluation plan, writing the implementation manual, identifying test markets, developing the advertising, and developing an administrative scheme.

To implement the pilot program, marketing and advertising needs to be initiated to encourage customers to participate in the pilot program. Specific transactions are developed and executed. The proposed pilot programs themselves are described in the sections that follow below.

In the evaluation phase, the success of program implementation is determined, including documenting installation of completed projects. The evaluation determines the actual kWh and kW savings from the program, as well as customer satisfaction with the program and its implementation. Based on these results, the program would be modified and improved. A cost-effectiveness calculation would be made to determine if the pilot program should be expanded to a full-scale program.

Full-scale development often will entail training additional field personnel and obtaining the equipment in the appropriate quantities. Once this is ready, the program can be expanded to additional markets.

#### 5.3.1.2 Pilot Programs for Buildings

Based on the results of customer research and the funding available, the following types of programs are suggested for the buildings sector:

- Informational Programs

  This program consists of brochures for customers on how to weatherstrip and caulk, add plastic to windows, cover windows during extreme cold, add insulation, select high-efficiency equipment, etc. It also includes advertising to encourage customers to conserve and demonstrate certain measures such as caulking and weatherstripping.



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- Building Energy Audits

  For this program, multi-family residential (apartment) buildings and institutional buildings would be audited.

  The audit would evaluate and report to the customer the cost-effectiveness of these measures. The customer could then decide which programs to implement. Incentives would be provided (under other programs) for certain measures.

- Heating System Efficiency Improvement Incentives

  This program would provide direct incentives to customers for improving efficiency of electrically heated homes through:

  - Weatherstripping
  - Caulking
  - Insulation
  - Window and door system modifications
  - Conversion to district or gas heat

- Water Heating System Efficiency Improvements

  - Direct incentives to customers for improving efficiency of electric hot water systems:

    -- Increase insulation on water heater tank
    -- Increase insulation on hot water pipes
    -- Install low-flow shower heads and faucets
    -- Convert to district or gas water heat

- Lighting Program

  - Provide incentives to replace low efficiency lights with higher efficiency lights. Also notes and recommends cleaning windows, fixtures and lamps.

- Conversion Electric Space and Water Heating to Natural Gas or Dual Fuel

  The steps in this process would identify villages and then buildings that could be converted to natural gas or dual fuel using gas as a backup. It would also be necessary to evaluate whether cooking as well as space and water heating should be changed. The steps in the evaluation would include:

  - Identify natural gas pipelines locations.
  - Find villages and towns near the pipeline. Identify those that mainly use electric heat.
  - Perform an cost-benefit evaluation of the conversion.
  - Determine the level of payment and participation by others such as gas company, residences or building owners.

- Low-Income Residential Programs

Specific programs should be developed, aimed at pensioners or other low-income individuals who cannot afford to pay for energy efficiency improvements to their homes.

#### 5.3.1.3 Pilot Industrial Programs

Based on the results of customer research and the funding available, the following types of programs are suggested for the industrial sector:

- Industrial Energy (Electricity) Audits

  This pilot program to co-sponsor audits, with a focus on electricity savings. Incentives to implement cost-effective recommendations from the audits should be provided under the other DSM programs. The audits, therefore, are a step that leads to many additional measures being installed.

- Electric Motor Operations and Maintenance Program

  In this program, experts would perform a one-time review of electric motor efficiency. These experts would most likely be from the private sector, operating under contract from NEK or the customer site with partial funding by NEK. The experts would also train the customers' personnel to perform

periodic reviews of the motors to maintain the efficiency at a high standard. The tasks to be performed include:

- Develop inventory of all motors over 10 kW
- Review efficiency of motors
- Develop specifications for new, high-efficiency motors for new applications or when existing motors wear out
- Perform benefit-cost analysis of early replacement of existing motors
- Survey existing motors for load (kW, kVAR, power factor), voltage on each phase, and efficiency of major motors
- Develop a power demand balance for the plant, under different operating conditions
- Check the tightness of V-belts to avoid slippage
- Review changes in operating procedures to improve energy efficiency
- Identify motors with excessive reactance for replacement or rewinding
- Review motor maintenance
- Evaluate replacement of oversized (underloaded) motors with more appropriate size motor
- Identify any phase-to-phase voltage imbalances and recommend corrections.

▸ Air Compressor Operations and Maintenance Program

This DSM program would review the motor/air compressor loads and the system for leaks. Like the motor O&M program, experts working on this program would provide training so that a review would be performed regularly.

- High-Efficiency Motor Incentives

  The program would provide part of the difference in costs between standard-efficiency equipment and high-efficiency equipment to encourage using high-efficiency equipment.

- Drives and Rotating Equipment Efficiency Incentives

  This program provides incentives for a variety of equipment upgrades pumps, fans, and compressors, as well as drive systems, such as variable speed drives.

- Industrial Lighting Program

  This program would provide incentives to upgrade lighting from incandescent to fluorescent, or from mercury vapor to high pressure sodium.

- Interruptible Tariffs

  The DBC industrial customer survey reported that 62% of the customers responding could curtail part of their load if offered a tariff incentive. This program will provide special tariffs for customers who agree to be used as first priority for load-shedding to prevent blackouts.

- Load Controllers

  This program would provide incentives to pay for part of the cost of installing a load control program and load control equipment to limit peak demand or shift some load off-peak.

- Energy Management System

  This program would provide incentives to install computer equipment to monitor energy usage and reports it to management and plant operators. This feedback allows plant operators to improve the efficiency of the operations. This technology was one of the most common recommendations in the AID-sponsored audits.

#### 5.3.1.4 Summary and Expected Results

The pilot programs will obtain experience with DSM technologies and customer response. The pilot programs will also develop and refine the approach for marketing the DSM programs.

The schedule for the program is 80 weeks, as indicated in Exhibit 5-29. There is some overlap because several activities can occur. The longest part of the schedule is in offering the program to the customers.

The budget for the DSM pilot program is $1.5 million estimated as follows:

| | |
|---|---|
| Program design and administration | $500,000 |
| DSM demonstration in buildings | 500,000 |
| DSM demonstration in industry | 500,000 |
| **Total** | **$1,500,000** |

**Exhibit 5-29**
**Schedule for Pilot Program Development**

| | |
|---|---|
| Project Start-Up | Week 0 |
| Market Research and Determine Incentive Levels | Week 1-8 |
| Program Design | Week 6-12 |
| Implementation | Week 13-80 |
| Evaluation | Week 60-80 |
| Preparation for Full-Scale Development | Week 60-80 |

### 5.3.2 Institutional Development

The actions required in this area include:

- Developing the legislative framework required for IRP in the legislation being developed concerning electricity
- Developing the regulatory framework (the institutions and regulations to carry out IRP according to the law)
- Establish organizational functions at NEK and the sales branches:
  - NEK Planning Department
    - Develops forecasts of demand and availability of supply-side resources
    - Analyzes long-run marginal cost of service
    - Prepares the IRP (supply and demand sides)

- Performs cost-benefit assessments of DSM measures and programs

- NEK DSM Department
  - Develops pilot programs to be implemented by branches
  - Trains branch personnel to implement program
  - Performs evaluations of program impacts
  - May perform major DSM studies for large customers.

- DSM Departments at the Sales Branches or Distribution Companies
  - Implements programs - works with customers, builders, ESCO, and other trade allies
  - Performs audits, or retains an independent firm to perform audits
  - Inspects applications to ensure that measures have been installed
  - Authorizes and pays customer (or ESCO) for measures that have been installed.
  - Carries out customer load research.

### 5.3.3 Load Research and DSM Assessment

#### 5.3.3.1 Customer Load Research

The characteristics of customers' use of energy is one of the most important factors in determining the future electric sector investment plan. There are very little detailed data on energy consumption by end use over the day or year. End-use load shape data are necessary for the complete analysis of DSM options.

A customer research group should be created at NEK (or other appropriate agency), and provided with the instrumentation required to carry out load research projects.

As part of the load research project, various sectors and types of types of loads are identified. Then, a sample of these loads are metered, and data are collected over a period of time to obtain information on peak demand and load shape.

Load research is usually an on-going process. Its initial use will be for DSM analysis. Later, load research can be used to evaluate the impact of DSM pilot programs. Load research is also used by many utilities for cost allocation and rate design.

The schedule should call for the design and development of the load research program for weather-sensitive loads over the spring and summer, with meters installed in the fall. Recordings would occur over the winter, and data analysis is scheduled for next spring.

Non-weather-sensitive loads such as industrial loads could be surveyed at the same time, or following the winter analysis by rotating the meters. Final results for this study are anticipated within one year, though this monitoring is expected to be on-going.

#### 5.3.3.2 DSM Assessment

Additional data on the costs of DSM measures and develops estimates of program impacts is needed to develop better estimates of the projection of the impact of DSM and for the economic analysis of DSM measures and programs.

In addition to load research, an appliance saturation survey of residential customers is needed to determine appliance saturation. An effective means of developing end-use data is to perform a conditional demand analysis (CDA) of the appliance saturation data. CDA uses statistical techniques to estimate average consumption by the appliances owned in households (refrigerators, water heaters, space heaters, lighting and other equipment). Given a baseline of actual appliance consumption, more accurate estimates of DSM impact can be developed.

Building simulation models should be considered for use in estimating the energy use by the structure or occupants. These types of models are particularly useful for simulating energy use for space heating based on heat losses through walls, windows, floors, and ceilings. The building simulation models would need to be based on survey, audit, or load research data.

Building simulation models can provide a baseline consumption level and then can examine the impact on energy use of installing DSM measures.

Building energy audits should also be performed to obtain data and identify the potential for DSM. These audits will obtain baseline data that cannot be adequately obtained by surveys. Approximately 200 walk-through audits will be performed in institutional buildings.

The detailed data obtained will be used to improve the DSM assessment provided in this report by giving load shape impact data and better data on the cost of implementing measures in Bulgaria. In this report, only peak demand and annual energy impact from a DSM option were considered; the detailed analysis will consider the load shape impact of the measure over the entire year. Detailed analysis uses computer programs such as DSManager (available from Electric Power Research Institute, EPRI).

The detailed DSM assessment is expected to be completed in 10 to 12 months.

# BULGARIA ELECTRICITY STUDY
# ELECTRICITY DEMAND FORECAST

Final Report

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# BULGARIA ELECTRICITY STUDY
# ELECTRICITY DEMAND FORECAST

Final Report

*Prepared for:*

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# EXECUTIVE SUMMARY

## S.1 INTRODUCTION

### S.1.1 Project Overview

This report presents partial results of work performed as part of the energy sector assistance provided to Bulgaria by the U.S. Agency for International Development. It was prepared as part of Task 1 - Electricity Sector Study and Action Plan, by RCG/Hagler, Bailly, Inc. as part of the A.I.D. Eastern Europe Regional Energy Efficiency Project's Energy Pricing, Energy Efficiency, and Energy Sector Restructuring Component. The report prepares a forecast of electricity demand.

Under Task 1 - Electricity Sector Study and Action Plan, Hagler, Bailly also prepared companion reports on the organization of the National Electric Company (NEK) and an assessment of the potential for Demand-side Management (DSM). Bechtel Corporation, under subcontract from Hagler Bailly, prepared a report on environmental improvement opportunities in thermal power generation, also under Task 1.

The objective of this study area was to develop a demand forecast for use in investment and operations planning.

The scope of the analysis was limited to analysis of the following data:

- reports and other published data provided by NEK and COE;
- electronic spreadsheets of monthly energy consumption for 1991-92 for 106 largest consumers, provided by NEK;
- survey of largest consumers, carried out by Hagler, Bailly and DBC on behalf of COE.

Hagler Bailly's analysis was carried out from October 1992 to February 1993, and resulted in the demand forecast described in this report. Near the end of this study period, the G-7 ordered the World Bank to carry out an assessment of electricity demand in Bulgaria, including development of a forecast. The World Bank reviewed the results of the latest forecast developed by NEK at the time, and adopted NEK's forecast for use in the report to the G-7. NEK's forecast fully reflected the consultations with Hagler Bailly over the period, and was markedly less optimistic than the forecasts which were first shown to the World Bank, USAID, Hagler

Bailly, and others in 1992. The NEK forecast is within the band of forecasting uncertainty of the Hagler Bailly forecast, and so we agree that the NEK forecast should be adopted for least cost planning studies.

### S.1.2 Background and Recent History of Electricity Demand

Beginning in 1990, the Bulgarian economy went into severe recession. Production decreased from most factories, traditional markets and trading partners were lost, centralized production structures were dismantled, state subsidies were cut drastically, prices increased, and unemployment grew rapidly. During this period, Bulgaria was faced with particularly acute energy problems, including power outages.

Total consumers' electric energy demand in Bulgaria in 1992 was 25% less than the maximum recorded in 1988. Reductions in annual energy sales (comparing 1992 with 1988) were 34% for industrial, 4% for households (no real price increases occurred in this sector until 1991), and 28% for other consumers (agriculture, transportation, public buildings). Analysis of the load duration curves reveals that most of the reduction in demand has occurred during summer months, and that some reduction has occurred during off-peak periods in the winter.

Peak power demand (absolute maximum gross MW recorded during the year) has reduced less than energy demand, and is now 15% less than the maximum recorded in 1989. During 1991 (the base year for this study), the maximum was recorded in January (7,500 MW), and August experienced the lowest peak (4,300 MW).

## S.2 RESULTS OF INDUSTRIAL ENERGY SURVEY

The largest industrial consumers in Bulgaria are judged to be at the greatest risk of losing their market, and their ability to cope with this dislocation will determine their survival, and thus their demand for electricity. To develop a better understanding of the conditions at these large consumers, a survey of the NEK's 106 largest electrical consumers was commissioned by RCG/Hagler Bailly as part of the project. Hagler Bailly subcontracted with DBC, a private Bulgarian firm, to carry out the work.

In general, the survey responses reflected the dire economic conditions and the need to find new markets. However, on balance it seems that these plants may have reached the bottom, with 1993 production and electricity usage not expected to decline much further.

According to NEK, Bulgaria now has nine large industrial cogenerators (with capacities of 20 MW or greater). Six of the 61 plants surveyed can generate their own electricity, but the survey discovered that two of these do not operate their generators regularly.

Electric motors and lighting are the dominant loads in the plants surveyed, and less than half have installed efficient lighting systems (such as high pressure sodium). Process loads are significant in the chemicals and metals industries for electrolysis, heat treatment, furnaces, and rolling mills.

Most plants surveyed are interested in energy conservation, and are willing to invest in such projects. Most have ideas for projects, but have not implemented them for lack of funds or for fear that they might disrupt production. Energy audits have been conducted in half the enterprises, but respondents indicated problems with the quality of the energy audits.

## S.3 DEMAND FORECAST

### S.3.1 Review of Previous Forecasts of Electricity Demand

Several forecasts of electricity demand in Bulgaria have been completed over the past several years. Prior forecasts differ because of differences in scenarios, differences in forecasting techniques, and differences in data. However, the more recent forecasts that build on the data obtained after the initiation of Bulgaria's transition to a market economy will more accurately capture the Bulgarian economy's energy response to this transition and the probable future of electricity demand.

The forecasts are summarized graphically in Exhibit S-3-1, and listed below.

- Forecast by NEK, the guidance from the World Bank, in 1992, with three variants:
  - -- most likely scenario
  - -- high demand scenario
  - -- low demand scenario
- Forecast by Equipe Cousteau for the EBRD in 1992
- Forecast by Prof. Gordon Hughes for the World Bank in 1991
- Energoproekt forecast 1991 (high and low demand scenarios)

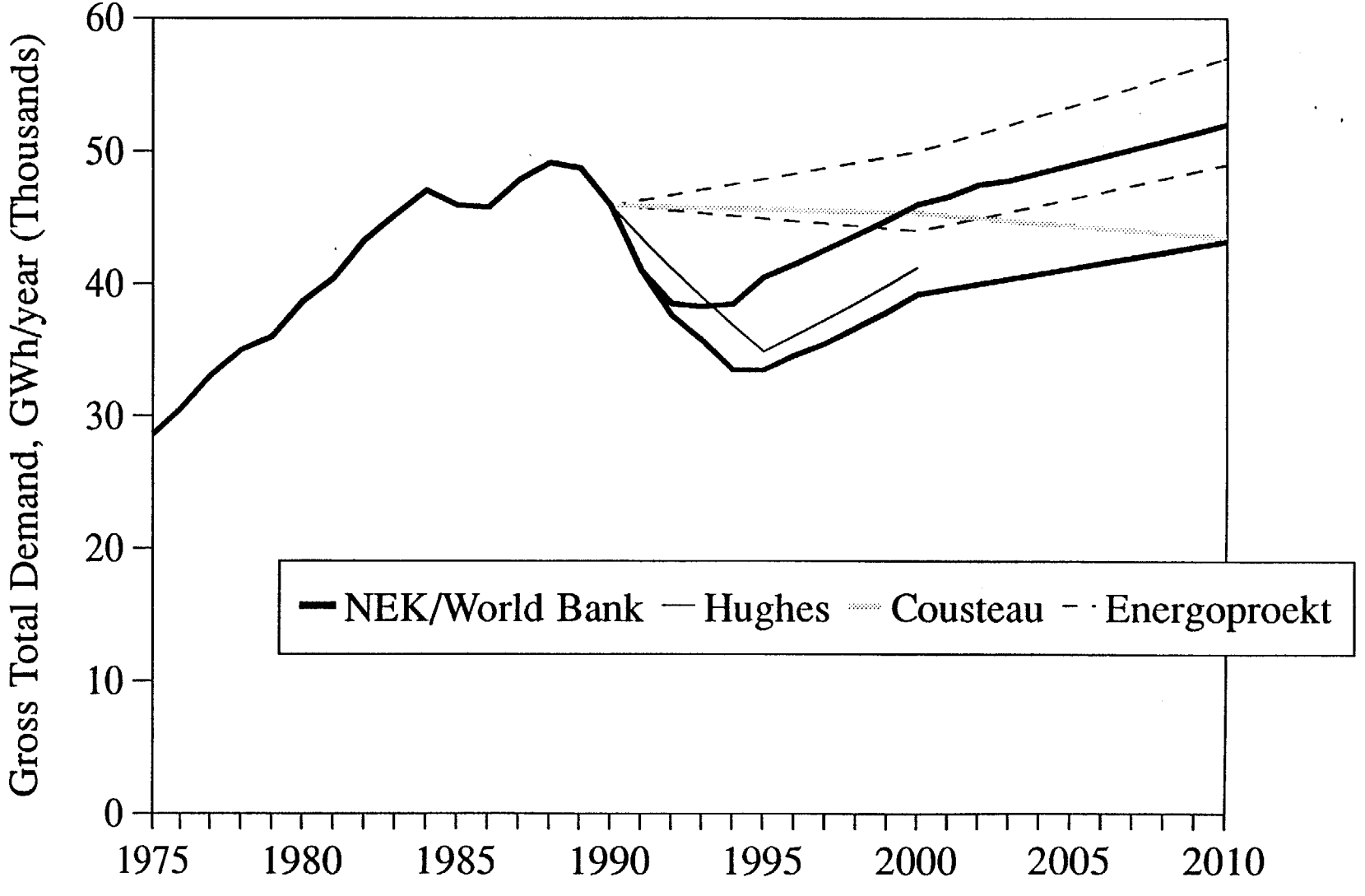
These forecasts establish a range of expected demand in the year 2000 from 35-50 TWh[1]. The spread of these forecasts indicates a high level of uncertainty.

[1] The NEK most likely scenario shows 46 TWh in year 2000.

Exhibit S-3-1

# Bulgaria - Total Electricity Demand

Comparison of Previous Forecasts

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### S.3.2 Scenarios Selected for Forecasting Electricity Demand

For the purposes of this report, three scenarios were developed. The scenario assumptions are summarized briefly in the table below, in terms of the economic growth, electricity efficiency, and other factors important to electricity demand:

| | ELECTRICITY DEMAND SCENARIOS | | |
|---|---|---|---|
| Variables | Moderate | Low | High |
| Economic Growth | low | low | high |
| Inflation | high | high | med |
| Electricity Prices | market | market | market |
| Industry DSM | low | med | high |
| Household DSM | low | med | high |

### S.3.3 Demand Forecasting Techniques

Separate forecasts were developed for households, industry, and the other sectors.

For households, we first developed an econometric equation based on income and price elasticities. The estimation used elasticities of income and price that are slightly higher than one would expect for a centralized economy and lower than that of a free market economy. The price elasticity was high, because the real price of electricity in Bulgaria generally declined for the last 12 years, with only variation from the long term trend in 1990 and 1991. The partial elasticities are:

| | |
|---|---|
| Elasticity of real income | 0.603 |
| Elasticity of real electricity price | -0.381 |

However, the analysis revealed that the large price increases expected in the first few years caused the forecast to drop below what we judged to be bare minimum for heating, cooking, and light. Therefore, we adjusted the results to account for these technical factors.

For industry, the survey (see above), together with consumption data for large customers and by industrial sector obtained from NEK, were used as the basis for a disaggregated approach, developing estimates of prospects for each of the large customers, and for each sector for 1993 and beyond.

We identified the electricity use patterns in the separate industries and developed forecasts of electricity use at this disaggregate industry level. We also identified those industries with more mature domestic markets and international markets that are most likely to succeed. In addition, estimates were made of the likely changes in electricity intensity in each industry in the future, as Bulgaria develops in the direction of the intensities in Western Europe industries. The speed of the changes will depend on the growth of domestic and international markets and the focus of the government programs.

The following industries were forecast as higher than average growth sectors: electrical equipment and electronics, glass and ceramics, agriculture, transportation and communication.

The following industries were forecast as relatively average growth sectors: non-ferrous metals, engineered metal products, textiles, food and beverage, construction, public sector buildings.

The following industries were forecast as lower than average growth sectors: iron & steel (ferrous metals), chemicals, building materials, timber, pulp & paper.

Future changes in peak demand will depend mainly on the possible recovery of equipment which has been shut down, or installation of new electrical equipment over time. Secondary effects will result from the future development of prices during peak periods, and the possible installation of demand control equipment. For the purposes of this analysis, these effects have been simulated by tracking the rate of change of GDP.

The demand forecasts are forecasts first of energy sales. The sales forecasts were then increased (to achieve "total demand") by adding estimated losses and station use of electricity. Station use was held constant at 11.1% of gross generation. Losses were brought back to a historical normal level of 11.5% (of energy for distribution) over a five year period. Exports and imports were ignored, and power purchases were held constant.

### S.3.4 Demand Forecast Results

A summary of the assumptions and results for the expected case is shown in Exhibit S-3-2.

- demand for electricity in the household sector continues to decline, reaching a minimum of 8,400 GWh in 1995, then climbs, reaching 11,000 GWh in 2010.
- in the industrial sector, demand drops slightly, with a minimum of 13,300 GWh in 1994-96, and then begins a gradual climb to 17,000 GWh in 2010.
- total electricity sales reach a minimum of 28,000 GWh in 1994-96 and then rise gradually to its 1988 level of 35,600 GWh around year 2008.
- peak demand reaches a minimum of 6,500 MW in 1994-95, then increases to 9,600 MW by 2010. The 1989 peak of 8,332 MW is reached again in year 2005.

**Exhibit S-3-2**
**BULGARIA**
**ELECTRICITY DEMAND FORECAST**
**EXPECTED CASE – MODERATE SCENARIO**

| | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **ASSUMPTIONS** | | | | | | | | | | | | | | | | | | |
| GDP Growth | −5.0% | −2.0% | 0.0% | 1.0% | 1.5% | 2.0% | 2.5% | 3.0% | 3.0% | 3.0% | 3.0% | 3.0% | 3.0% | 3.0% | 3.0% | 3.0% | 3.0% | 3.0% |
| Real Electricity Price Changes | | | | | | | | | | | | | | | | | | |
| Households | 75.0% | 50.0% | 25.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| Industry | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| Population Growth | 0.2% | 0.2% | 0.2% | 0.2% | 0.2% | 0.2% | 0.2% | 0.2% | 0.2% | 0.2% | 0.2% | 0.2% | 0.2% | 0.2% | 0.2% | 0.2% | 0.2% | 0.2% |
| **Changes in Industrial Electricity Intensity** | | | | | | | | | | | | | | | | | | |
| Growth Sectors | −4.0% | 0.0% | 5.0% | 8.5% | 11.5% | 17.0% | 22.5% | 18.0% | 18.0% | 13.0% | 13.0% | 13.0% | 10.5% | 10.5% | 10.5% | 10.5% | 8.0% | 8.0% |
| Constant Sectors | −6.0% | −3.0% | 0.0% | 1.0% | 1.5% | 3.0% | 3.5% | 4.0% | 4.0% | 4.0% | 4.0% | 4.0% | 4.0% | 4.0% | 4.0% | 4.0% | 4.0% | 4.0% |
| Declining Sectors | −9.0% | −6.0% | −4.0% | −3.0% | 0.5% | 1.0% | 2.5% | 3.0% | 3.0% | 3.0% | 3.0% | 3.0% | 3.0% | 3.0% | 3.0% | 3.0% | 3.0% | 3.0% |
| **FORECAST OF ELECTRICITY SALES, GWh/year** | | | | | | | | | | | | | | | | | | |
| Household Sector | 8,990 | 8,548 | 8,398 | 8,465 | 8,559 | 8,681 | 8,830 | 9,008 | 9,190 | 9,376 | 9,565 | 9,759 | 9,956 | 10,157 | 10,362 | 10,572 | 10,785 | 11,003 |
| Industry Sector | 13,484 | 13,296 | 13,267 | 13,303 | 13,417 | 13,621 | 13,898 | 14,186 | 14,485 | 14,762 | 15,047 | 15,339 | 15,620 | 15,907 | 16,202 | 16,502 | 16,788 | 17,079 |
| Other Sectors | 6,050 | 6,090 | 6,182 | 6,301 | 6,411 | 6,480 | 6,564 | 6,662 | 6,762 | 6,846 | 6,931 | 7,017 | 7,104 | 7,192 | 7,282 | 7,372 | 7,464 | 7,557 |
| **Total Sales** | **28,525** | **27,934** | **27,847** | **28,070** | **28,387** | **28,782** | **29,291** | **29,856** | **30,437** | **30,984** | **31,543** | **32,114** | **32,680** | **33,257** | **33,846** | **34,447** | **35,037** | **35,639** |
| **FORECAST OF GENERATION REQUIREMENTS, GWh/year** | | | | | | | | | | | | | | | | | | |
| Distribution Losses | 4,119 | 3,887 | 3,725 | 3,603 | 3,489 | 3,534 | 3,592 | 3,656 | 3,721 | 3,782 | 3,844 | 3,908 | 3,970 | 4,034 | 4,099 | 4,165 | 4,230 | 4,295 |
| Losses (pct of for distribution) | 13.5% | 13.0% | 12.5% | 12.0% | 11.5% | 11.5% | 11.5% | 11.5% | 11.5% | 11.5% | 11.5% | 11.5% | 11.5% | 11.5% | 11.5% | 11.5% | 11.5% | 11.5% |
| For Distribution | 30,509 | 29,897 | 29,798 | 30,023 | 30,341 | 30,732 | 31,238 | 31,792 | 32,360 | 32,889 | 33,429 | 33,981 | 34,524 | 35,077 | 35,642 | 36,218 | 36,780 | 37,352 |
| Power Purchases from Factories & Others | 750 | 750 | 750 | 750 | 750 | 750 | 750 | 750 | 750 | 750 | 750 | 750 | 750 | 750 | 750 | 750 | 750 | 750 |
| Imports | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Exports | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Factory Self-Generation | 3,024 | 2,975 | 2,975 | 2,999 | 3,035 | 3,084 | 3,145 | 3,221 | 3,298 | 3,377 | 3,458 | 3,541 | 3,626 | 3,713 | 3,803 | 3,894 | 3,987 | 4,083 |
| Power Plant Auxiliaries | 4,058 | 3,975 | 3,961 | 3,992 | 4,035 | 4,089 | 4,157 | 4,233 | 4,310 | 4,383 | 4,456 | 4,531 | 4,606 | 4,681 | 4,758 | 4,837 | 4,913 | 4,991 |
| Auxiliaries (pct of gross generation) | 11.1% | 11.1% | 11.1% | 11.2% | 11.2% | 11.2% | 11.2% | 11.2% | 11.2% | 11.2% | 11.2% | 11.2% | 11.2% | 11.2% | 11.1% | 11.1% | 11.1% | 11.1% |
| **Gross Total Demand** | **36,701** | **35,795** | **35,533** | **35,664** | **35,912** | **36,405** | **37,041** | **37,745** | **38,469** | **39,149** | **39,843** | **40,554** | **41,256** | **41,972** | **42,703** | **43,448** | **44,180** | **44,926** |
| Peak Demand (MW) | 6,650 | 6,517 | 6,517 | 6,582 | 6,681 | 6,815 | 6,985 | 7,194 | 7,410 | 7,633 | 7,862 | 8,097 | 8,340 | 8,591 | 8,848 | 9,114 | 9,387 | 9,669 |

EXHS-3-2.wk1

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The low demand case is shown in Exhibit S-3-3.

- demand for electricity in the household sector continues to decline, reaching a minimum of 8,000 GWh in 1995, then climbs, reaching 10,000 GWh in 2010.
- in the industrial sector, demand continues to drop, with a minimum of 12,500 GWh in 1996-97, and then begins a gradual climb to 15,000 GWh in 2010.
- total electricity sales reach a minimum of 26,600 GWh in 1995-96 and then rise gradually to 32,000 GWh in year 2010, but never reach the 1988 level of 35,600 GWh.
- peak demand reaches a minimum of 6,100 MW in 1994-97, then increases to 8,300 MW by 2010, the same as the historical maximum of 8,332 recorded in 1989.



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**Exhibit S–3–3**
**BULGARIA**
**ELECTRICITY DEMAND FORECAST**
**LOW DEMAND SCENARIO**

| | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **ASSUMPTIONS** | | | | | | | | | | | | | | | | | | |
| GDP Growth | –9.0% | –4.0% | –1.0% | 0.0% | 1.0% | 1.5% | 2.0% | 2.5% | 2.5% | 2.5% | 2.5% | 2.5% | 2.5% | 2.5% | 2.5% | 2.5% | 2.5% | 2.5% |
| Real Electricity Price Changes | | | | | | | | | | | | | | | | | | |
| Households | 75.0% | 50.0% | 25.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| Industry | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| Population Growth | 0.2% | 0.2% | 0.2% | 0.2% | 0.2% | 0.2% | 0.2% | 0.2% | 0.2% | 0.2% | 0.2% | 0.2% | 0.2% | 0.2% | 0.2% | 0.2% | 0.2% | 0.2% |
| **Changes in Industrial Electricity Intensity** | | | | | | | | | | | | | | | | | | |
| Growth Sectors | –9.0% | –3.0% | 1.5% | 5.0% | 8.5% | 11.5% | 12.0% | 12.5% | 12.5% | 12.5% | 12.5% | 12.5% | 10.0% | 10.0% | 10.0% | 10.0% | 7.5% | 7.5% |
| Constant Sectors | –12.0% | –7.0% | –3.0% | –1.0% | 1.0% | 2.5% | 3.0% | 3.5% | 3.5% | 3.5% | 3.5% | 3.5% | 3.5% | 3.5% | 3.5% | 3.5% | 3.5% | 3.5% |
| Declining Sectors | –17.0% | –11.5% | –8.0% | –5.0% | –4.0% | –3.5% | –0.5% | 1.5% | 2.5% | 2.5% | 2.5% | 2.5% | 2.5% | 2.5% | 2.5% | 2.5% | 2.5% | 2.5% |
| **FORECAST OF ELECTRICITY SALES, GWh/year** | | | | | | | | | | | | | | | | | | |
| Household Sector | 8,759 | 8,221 | 8,027 | 8,043 | 8,108 | 8,198 | 8,314 | 8,457 | 8,602 | 8,750 | 8,900 | 9,053 | 9,208 | 9,366 | 9,527 | 9,691 | 9,857 | 10,027 |
| Industry Sector | 13,186 | 12,777 | 12,582 | 12,510 | 12,536 | 12,634 | 12,789 | 12,990 | 13,207 | 13,430 | 13,658 | 13,892 | 14,116 | 14,344 | 14,578 | 14,816 | 15,041 | 15,269 |
| Other Sectors | 5,948 | 5,935 | 5,996 | 6,085 | 6,179 | 6,234 | 6,302 | 6,383 | 6,466 | 6,533 | 6,601 | 6,670 | 6,739 | 6,809 | 6,880 | 6,952 | 7,025 | 7,098 |
| **Total Sales** | **27,893** | **26,933** | **26,605** | **26,638** | **26,822** | **27,065** | **27,404** | **27,830** | **28,275** | **28,713** | **29,159** | **29,614** | **30,063** | **30,520** | **30,985** | **31,459** | **31,923** | **32,394** |
| **FORECAST OF GENERATION REQUIREMENTS, GWh/year** | | | | | | | | | | | | | | | | | | |
| Distribution Losses | 4,038 | 3,761 | 3,573 | 3,435 | 3,313 | 3,340 | 3,378 | 3,426 | 3,476 | 3,525 | 3,575 | 3,626 | 3,676 | 3,727 | 3,778 | 3,831 | 3,882 | 3,934 |
| Losses (pct of for distribution) | 13.5% | 13.0% | 12.5% | 12.0% | 11.5% | 11.5% | 11.5% | 11.5% | 11.5% | 11.5% | 11.5% | 11.5% | 11.5% | 11.5% | 11.5% | 11.5% | 11.5% | 11.5% |
| For Distribution | 29,910 | 28,930 | 28,585 | 28,623 | 28,805 | 29,042 | 29,373 | 29,788 | 30,224 | 30,650 | 31,085 | 31,528 | 31,963 | 32,405 | 32,855 | 33,313 | 33,759 | 34,211 |
| **Power Purchases from Factories & Others** | 750 | 750 | 750 | 750 | 750 | 750 | 750 | 750 | 750 | 750 | 750 | 750 | 750 | 750 | 750 | 750 | 750 | 750 |
| Imports | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Exports | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Factory Self–Generation | 2,923 | 2,829 | 2,807 | 2,807 | 2,829 | 2,863 | 2,909 | 2,967 | 3,027 | 3,087 | 3,149 | 3,212 | 3,276 | 3,342 | 3,408 | 3,477 | 3,546 | 3,617 |
| Power Plant Auxiliaries | 3,976 | 3,843 | 3,796 | 3,801 | 3,826 | 3,858 | 3,903 | 3,960 | 4,019 | 4,077 | 4,137 | 4,197 | 4,256 | 4,317 | 4,378 | 4,440 | 4,501 | 4,563 |
| Auxiliaries (pct of gross generation) | 11.1% | 11.1% | 11.2% | 11.2% | 11.3% | 11.3% | 11.3% | 11.2% | 11.2% | 11.2% | 11.2% | 11.2% | 11.2% | 11.2% | 11.2% | 11.2% | 11.2% | 11.2% |
| **Gross Total Demand** | **35,907** | **34,536** | **33,974** | **33,874** | **33,960** | **34,263** | **34,685** | **35,215** | **35,770** | **36,315** | **36,870** | **37,437** | **37,995** | **38,563** | **39,142** | **39,730** | **40,306** | **40,891** |
| **Peak Demand (MW)** | **6,370** | **6,115** | **6,054** | **6,054** | **6,115** | **6,206** | **6,330** | **6,489** | **6,651** | **6,817** | **6,988** | **7,162** | **7,341** | **7,525** | **7,713** | **7,906** | **8,103** | **8,306** |

EXHS-3-3.WK1

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The high demand case is shown in Exhibit S-3-4.

- demand for electricity in the household sector declines slightly, reaching a minimum of 8,700 GWh in 1995, then climbs, reaching 12,800 GWh in 2010.
- in the industrial sector, demand holds firm at 13,600 GWh until 1996, and then begins a gradual climb to 19,500 GWh in 2010.
- total electricity sales reach a minimum of 28,700 GWh in 1994 and then rise gradually to 41,000 GWh in year 2010, but never reach the 1988 level of 35,600 GWh.
- peak demand holds at 6,900 MW until 1996, then increases to 12,300 MW by 2010, passing the historical maximum of 8,332 in year 2002.

**Exhibit S-3-4**
**BULGARIA**
**ELECTRICITY DEMAND FORECAST**
**HIGH DEMAND SCENARIO**

| | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **ASSUMPTIONS** | | | | | | | | | | | | | | | | | | |
| GDP Growth | -2.0% | 0.0% | 1.0% | 1.5% | 2.0% | 2.8% | 3.3% | 4.5% | 4.5% | 4.5% | 4.5% | 4.5% | 4.5% | 4.5% | 4.5% | 4.5% | 4.5% | 4.5% |
| Real Electricity Price Changes | | | | | | | | | | | | | | | | | | |
| Households | 75.0% | 50.0% | 25.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| Industry | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| Population Growth | 0.2% | 0.2% | 0.2% | 0.2% | 0.2% | 0.2% | 0.2% | 0.2% | 0.2% | 0.2% | 0.2% | 0.2% | 0.2% | 0.2% | 0.2% | 0.2% | 0.2% | 0.2% |
| **Changes in Industrial Electricity Intensity** | | | | | | | | | | | | | | | | | | |
| Growth Sectors | 0.0% | 2.0% | 4.0% | 6.5% | 9.5% | 12.8% | 18.3% | 24.5% | 19.5% | 14.5% | 14.5% | 14.5% | 12.0% | 12.0% | 12.0% | 12.0% | 9.5% | 9.5% |
| Constant Sectors | -3.0% | 0.0% | 1.0% | 1.5% | 3.0% | 4.8% | 6.3% | 9.5% | 8.5% | 7.5% | 6.5% | 5.5% | 5.5% | 5.5% | 5.5% | 5.5% | 5.5% | 5.5% |
| Declining Sectors | -7.0% | -4.0% | -2.0% | -0.5% | 1.0% | 1.8% | 2.8% | 4.5% | 4.5% | 4.5% | 4.5% | 4.5% | 4.5% | 4.5% | 4.5% | 4.5% | 4.5% | 4.5% |
| **FORECAST OF ELECTRICITY SALES, GWh/year** | | | | | | | | | | | | | | | | | | |
| Household Sector | 9,164 | 8,824 | 8,723 | 8,820 | 8,944 | 9,112 | 9,310 | 9,583 | 9,863 | 10,153 | 10,450 | 10,757 | 11,072 | 11,396 | 11,731 | 12,074 | 12,428 | 12,793 |
| Industry Sector | 13,616 | 13,572 | 13,601 | 13,680 | 13,849 | 14,112 | 14,480 | 15,047 | 15,572 | 16,043 | 16,488 | 16,902 | 17,309 | 17,728 | 18,158 | 18,600 | 19,031 | 19,472 |
| Other Sectors | 6,145 | 6,325 | 6,537 | 6,729 | 6,918 | 7,075 | 7,224 | 7,388 | 7,553 | 7,698 | 7,843 | 7,987 | 8,135 | 8,285 | 8,437 | 8,593 | 8,751 | 8,912 |
| **Total Sales** | **28,925** | **28,721** | **28,861** | **29,229** | **29,711** | **30,299** | **31,014** | **32,018** | **32,988** | **33,894** | **34,781** | **35,646** | **36,516** | **37,409** | **38,326** | **39,267** | **40,210** | **41,177** |
| **FORECAST OF GENERATION REQUIREMENTS, GWh/year** | | | | | | | | | | | | | | | | | | |
| Distribution Losses | 4,168 | 3,984 | 3,847 | 3,738 | 3,638 | 3,705 | 3,787 | 3,902 | 4,012 | 4,113 | 4,210 | 4,305 | 4,399 | 4,495 | 4,594 | 4,696 | 4,797 | 4,900 |
| Losses (pct of for distribution) | 13.5% | 13.0% | 12.5% | 12.0% | 11.5% | 11.5% | 11.5% | 11.5% | 11.5% | 11.5% | 11.5% | 11.5% | 11.5% | 11.5% | 11.5% | 11.5% | 11.5% | 11.5% |
| For Distribution | 30,877 | 30,646 | 30,776 | 31,149 | 31,637 | 32,221 | 32,933 | 33,930 | 34,884 | 35,761 | 36,611 | 37,431 | 38,250 | 39,090 | 39,950 | 40,832 | 41,709 | 42,607 |
| **Power Purchases from Factories & Others** | 750 | 750 | 750 | 750 | 750 | 750 | 750 | 750 | 750 | 750 | 750 | 750 | 750 | 750 | 750 | 750 | 750 | 750 |
| Imports | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Exports | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Factory Self-Generation | 3,099 | 3,099 | 3,124 | 3,162 | 3,212 | 3,283 | 3,368 | 3,489 | 3,615 | 3,745 | 3,880 | 4,020 | 4,164 | 4,314 | 4,470 | 4,631 | 4,797 | 4,970 |
| Power Plant Auxiliaries | 4,108 | 4,077 | 4,094 | 4,145 | 4,212 | 4,292 | 4,389 | 4,525 | 4,655 | 4,774 | 4,890 | 5,002 | 5,114 | 5,228 | 5,345 | 5,466 | 5,585 | 5,708 |
| Auxiliaries (pct of gross generation) | 11.0% | 11.1% | 11.1% | 11.2% | 11.2% | 11.2% | 11.2% | 11.2% | 11.2% | 11.2% | 11.1% | 11.1% | 11.1% | 11.1% | 11.1% | 11.1% | 11.0% | 11.0% |
| **Gross Total Demand** | **37,202** | **36,782** | **36,803** | **37,112** | **37,561** | **38,296** | **39,190** | **40,444** | **41,654** | **42,781** | **43,881** | **44,952** | **46,028** | **47,132** | **48,265** | **49,428** | **50,592** | **51,785** |
| **Peak Demand (MW)** | **6,860** | **6,860** | **6,929** | **7,033** | **7,173** | **7,370** | **7,610** | **7,952** | **8,310** | **8,684** | **9,075** | **9,483** | **9,910** | **10,356** | **10,822** | **11,309** | **11,818** | **12,350** |

EXHS-3-4.WK1

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### S.3.5 Comparison of Demand Forecasts

These three scenarios are compared in a series of graphs. Each graph also shows the historical situation since 1975, for clarity.

- A comparison of the changes in the total domestic sales of electricity are provided in Exhibit S-3-5. In year 2000, the high scenario has a 15% greater level of electricity demand than the low scenario.

- Gross total electricity demand, including power plant auxiliaries and distribution losses, is shown in Exhibit S-3-6.

- Annual maximum peak demand is illustrated in Exhibit S-3-7, and shows a different pattern, consistent with the economic restructuring away from heavy industry.

Exhibit S-3-5

# Bulgaria - Total Domestic Sales

Comparison of Scenarios

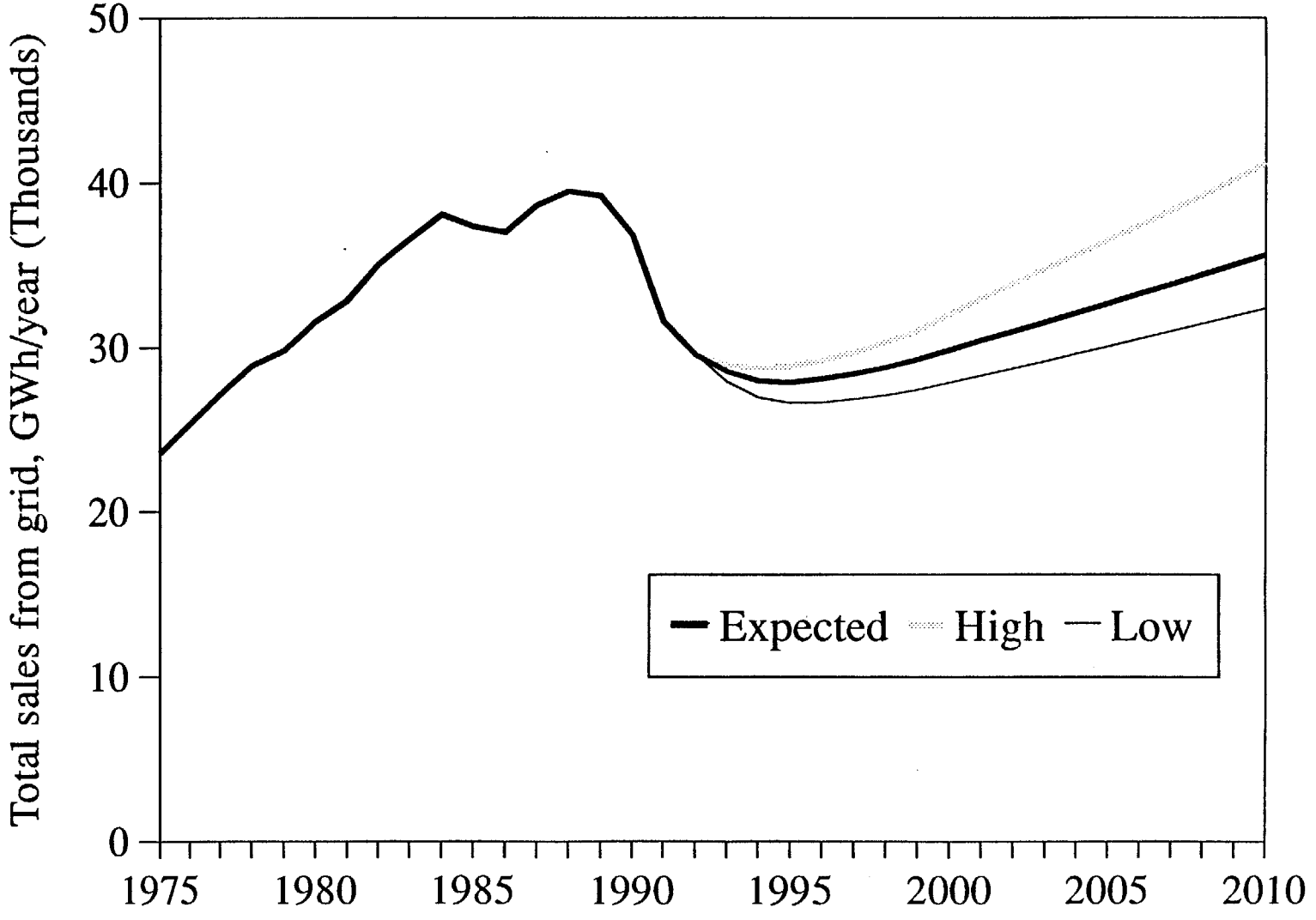


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Exhibit S-3-6

# Bulgaria - Total Electricity Demand

Comparison of Scenarios

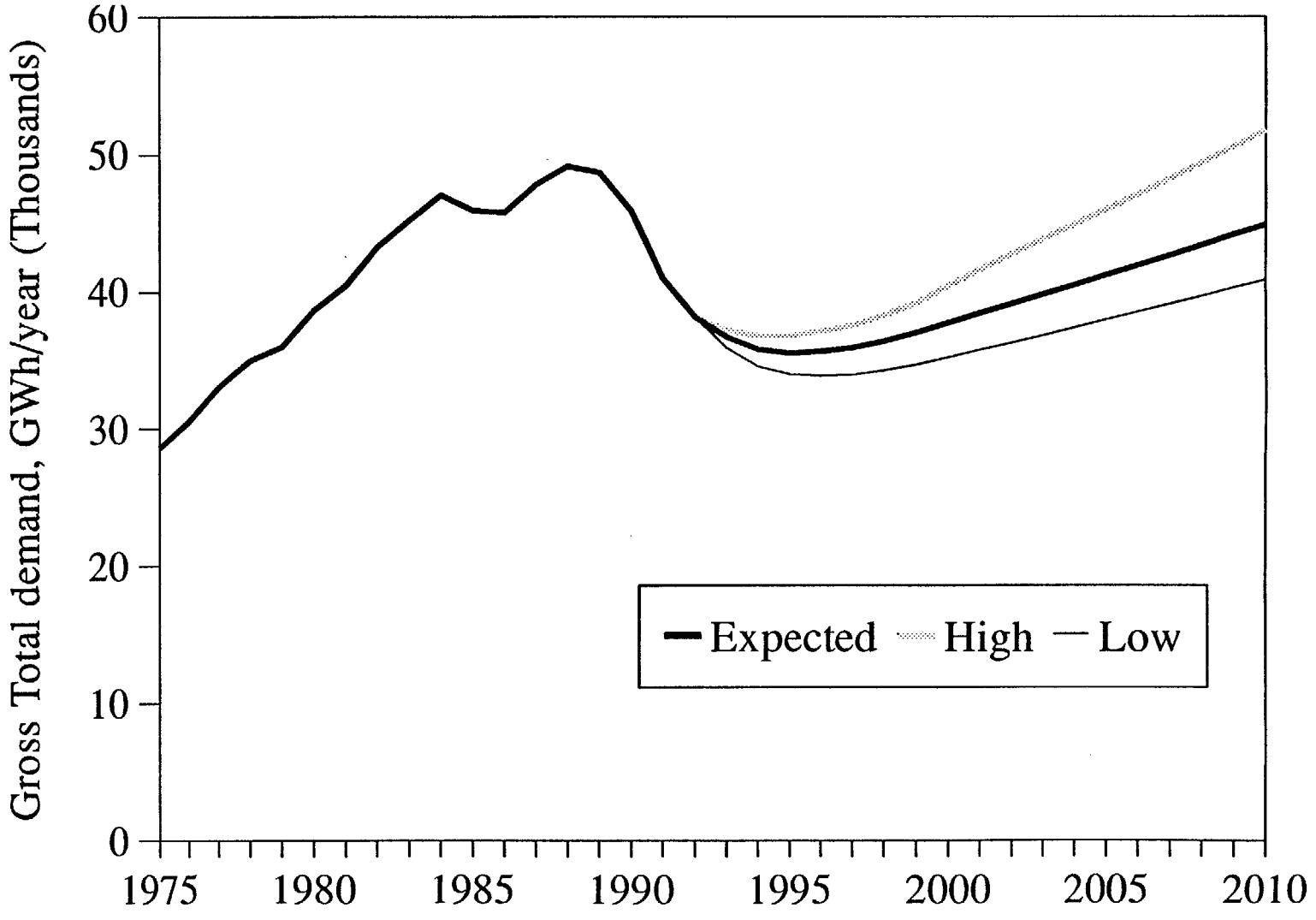
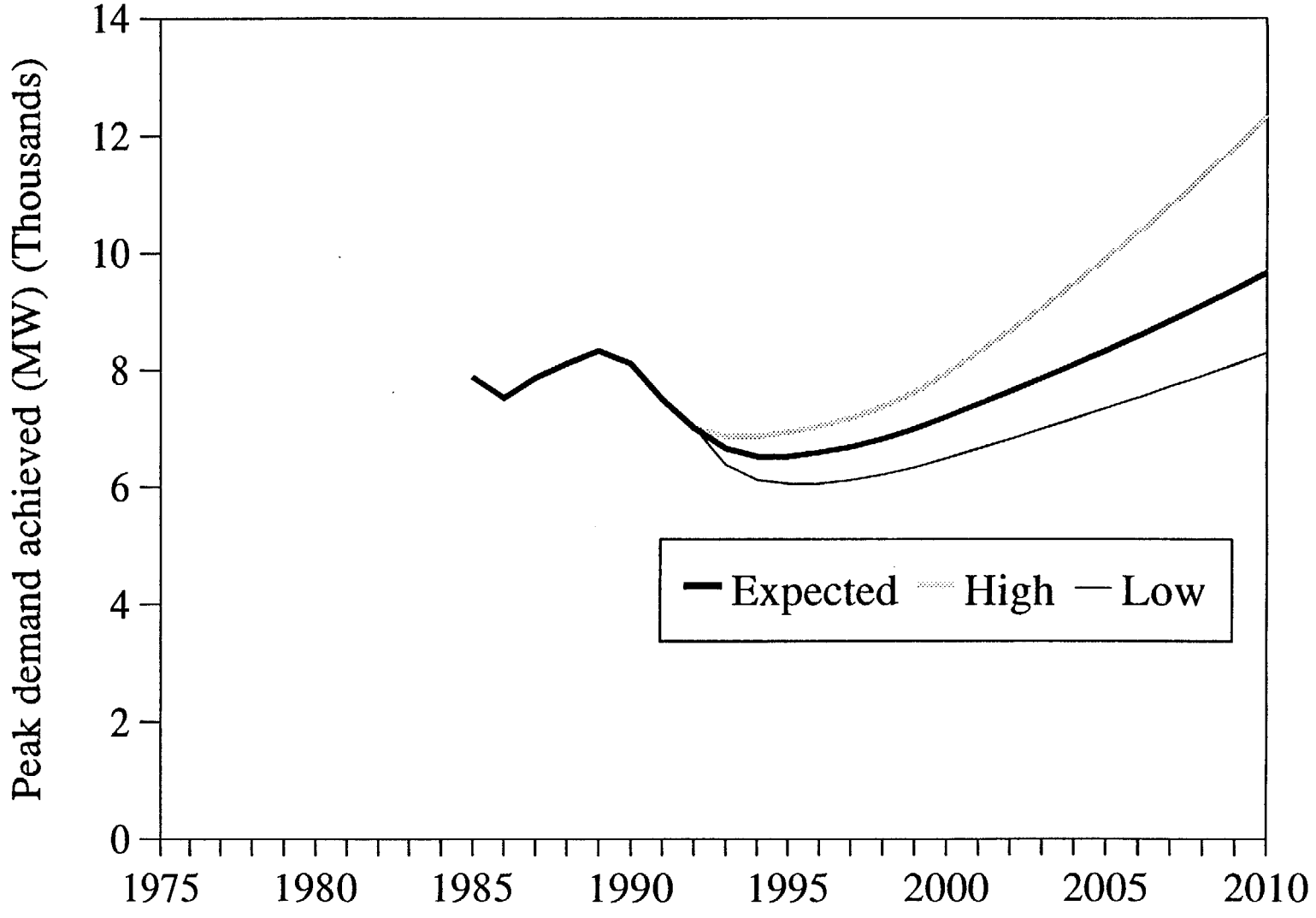


Exhibit S-3-7

# Bulgaria - Annual Peak Demand

Comparison of Scenarios

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# 1. INTRODUCTION

## 1.1 PROJECT OVERVIEW

This report presents partial results of work performed as part of the energy sector assistance provided to Bulgaria by the U.S. Agency for International Development. It was prepared as part of Task 1 - Electricity Sector Study and Action Plan, by RCG/Hagler, Bailly, Inc. as part of the A.I.D. Eastern Europe Regional Energy Efficiency Project's Energy Pricing, Energy Efficiency, and Energy Sector Restructuring Component. The report prepares a forecast of electricity demand.

Under Task 1 - Electricity Sector Study and Action Plan, Hagler, Bailly also prepared companion reports on the organization of the National Electric Company (NEK) and an assessment of the potential for Demand-side Management (DSM). Bechtel Corporation, under subcontract from Hagler Bailly, prepared a report on environmental improvement opportunities in thermal power generation, also under Task 1.

The objective of this study area was to develop a demand forecast for use in investment and operations planning.

The scope of the analysis was limited to analysis of the following data:

- reports and other published data provided by NEK and COE;
- electronic spreadsheets of monthly energy consumption for 1991-92 for 106 largest consumers, provided by NEK;
- survey of largest consumers, carried out by Hagler, Bailly and DBC on behalf of COE.

Hagler Bailly's analysis was carried out from October 1992 to February 1993, and resulted in the demand forecast described in this report. Near the end of this study period, the G-7 ordered the World Bank to carry out an assessment of electricity demand in Bulgaria, including development of a forecast. The World Bank reviewed the results of the latest forecast developed by NEK at the time, and adopted NEK's forecast for use in the report to the G-7. NEK's forecast fully reflected the consultations with Hagler Bailly over the period, and was markedly less optimistic than the forecasts which were first shown to the World Bank, USAID, Hagler Bailly, and others in 1992. The NEK forecast is within the band of forecasting uncertainty of the Hagler Bailly forecast, and so we agree that the NEK forecast should be adopted for least

cost planning studies.

## 1.2 HISTORICAL ELECTRICITY USE

In 1991 total installed capacity in Bulgaria was 12,074 MW, of which 10,460 MW is owned by NEK. District heating companies have an installed capacity of 574 MW in combined heat and power . Industrial enterprises have an installed capacity of 1,040 MW, mostly also combined heat and power.

Exhibit 1-1 illustrates the historical electrical energy balance in Bulgaria for 1975 and 1980-92.

## Exhibit 1–1

## BULGARIA
## HISTORICAL ELECTRICITY BALANCE

| | GWh/year | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1975 | 1980 | 1981 | 1982 | 1983 | 1984 | 1985 | 1986 | 1987 | 1988 | 1989 | 1990 | 1991 | 1992 |
| **Gross Generation** | **24,965** | **34,841** | **37,045** | **40,634** | **42,863** | **44,672** | **41,633** | **41,821** | **43,474** | **45,007** | **44,327** | **42,121** | **38,891** | **36,437** |
| Power Plant Auxiliaries | 2,668 | 3,640 | 3,897 | 4,315 | 4,577 | 4,661 | 4,544 | 4,595 | 4,766 | 4,897 | 4,841 | 4,623 | 4,221 | 3,986 |
| Auxiliaries (pct of net production) | 10.7% | 10.4% | 10.5% | 10.6% | 10.7% | 10.4% | 10.9% | 11.0% | 11.0% | 10.9% | 10.9% | 11.0% | 10.9% | 10.9% |
| **Net Generation** | **22,296** | **31,201** | **33,148** | **36,319** | **38,286** | **40,011** | **37,089** | **37,226** | **38,708** | **40,110** | **39,486** | **37,498** | **34,670** | **32,451** |
| Imports | 3,902 | 4,698 | 4,497 | 4,441 | 4,582 | 4,636 | 5,959 | 4,571 | 4,673 | 4,450 | 4,937 | 5,387 | 3,082 | 2,700 |
| Exports | 279 | 866 | 1,095 | 1,794 | 2,221 | 2,243 | 1,655 | 599 | 324 | 304 | 548 | 1,597 | 959 | 1,000 |
| Power Purchases from Factories & Others | | | | | | | | | | 773 | 774 | 735 | 754 | 750 |
| **Total For Distribution** | **25,920** | **35,033** | **36,551** | **38,966** | **40,647** | **42,403** | **41,393** | **41,198** | **43,056** | **44,256** | **43,875** | **41,288** | **36,793** | **34,151** |
| Distribution Losses | 2,387 | 3,454 | 3,695 | 3,888 | 4,046 | 4,301 | 4,016 | 4,170 | 4,413 | 4,762 | 4,656 | 4,443 | 5,191 | 4,576 |
| Losses (pct of for distribution) | 9.2% | 9.9% | 10.1% | 10.0% | 10.0% | 10.1% | 9.7% | 10.1% | 10.2% | 10.8% | 10.6% | 10.8% | 14.1% | 13.4% |
| **Final Sales** | **23,533** | **31,579** | **32,856** | **35,077** | **36,601** | **38,102** | **37,376** | **37,027** | **38,643** | **39,494** | **39,219** | **36,845** | **31,602** | **29,575** |
| Household Sector | 4,588 | 6,844 | 6,992 | 8,105 | 8,516 | 9,444 | 9,552 | 8,685 | 9,445 | 9,935 | 10,183 | 10,475 | 10,404 | 9,541 |
| Industry Sector | 14,306 | 17,524 | 18,498 | 19,227 | 20,004 | 20,414 | 20,038 | 20,283 | 20,674 | 21,208 | 20,815 | 19,386 | 15,013 | 14,013 |
| Other Sectors | 4,640 | 7,211 | 7,366 | 7,746 | 8,081 | 8,244 | 7,786 | 8,059 | 8,524 | 8,351 | 8,221 | 6,984 | 6,185 | 6,021 |
| Factory Self–Generation | 3,000 | 4,500 | 4,500 | 4,500 | 4,500 | 4,553 | 4,688 | 4,378 | 4,435 | 4,339 | 4,281 | 3,751 | 3,547 | 3,150 |
| **Total Consumers' Demand** | **26,533** | **36,079** | **37,356** | **39,577** | **41,101** | **42,655** | **42,064** | **41,405** | **43,078** | **43,833** | **43,500** | **40,596** | **35,149** | **32,725** |
| **Gross Peak Demand (MW)** | | **6,922** | | | | | **7,878** | **7,514** | **7,853** | **8,114** | **8,332** | **8,111** | **7,489** | **7,500** |
| Load factor | | | | | | | | | | | | | | |
| based on Total for Distribution | | 0.58 | | | | | 0.60 | 0.63 | 0.63 | 0.62 | 0.60 | 0.58 | 0.56 | 0.52 |
| based on Net Generation | | 0.51 | | | | | 0.54 | 0.57 | 0.56 | 0.56 | 0.54 | 0.53 | 0.53 | 0.49 |
| based on Gross Generation | | 0.57 | | | | | 0.60 | 0.64 | 0.63 | 0.63 | 0.61 | 0.59 | 0.59 | 0.55 |

HISTOR.WK1

Key points shown in Exhibit 1-1 include the following:

- Total consumers' electric energy demand in Bulgaria has taken a sharp drop, and is now 25% less than the maximum recorded in 1988. After dropping about 6% in 1990, total energy demand plummeted more than 13% during 1991 and dropped a further 7% during 1992.

- However, the reduction in electricity usage was not uniform across all sectors. Until 1992, the drop in demand was concentrated, for the most part, in the industrial sector as this sector fought to adjust to a market economy.

- Transmission and distribution losses increased substantially in 1991. This is probably due to energy diversion following increases in tariffs.

- Peak power demand (absolute maximum recorded during the year) has reduced, but much less than energy demand, and is now 15% less than the maximum recorded in 1989. The drop in 1990 (from 8,332 MW to 8,111 MW) amounted to 2.6% and in 1991 a further 7.7% to 7,489 MW and finally to 7,050 MW in 1992.

- Classifying energy sales (GWH/year) into three groups, reductions since 1988 are as follows:
  - -- industrial sales are down 34%
  - -- household sales are down 4%
  - -- other (agriculture, transportation, public buildings) sales are down 28%

- Power generation by industrial enterprises peaked in 1985 at 4,688 GWh, and has since declined by 33%.

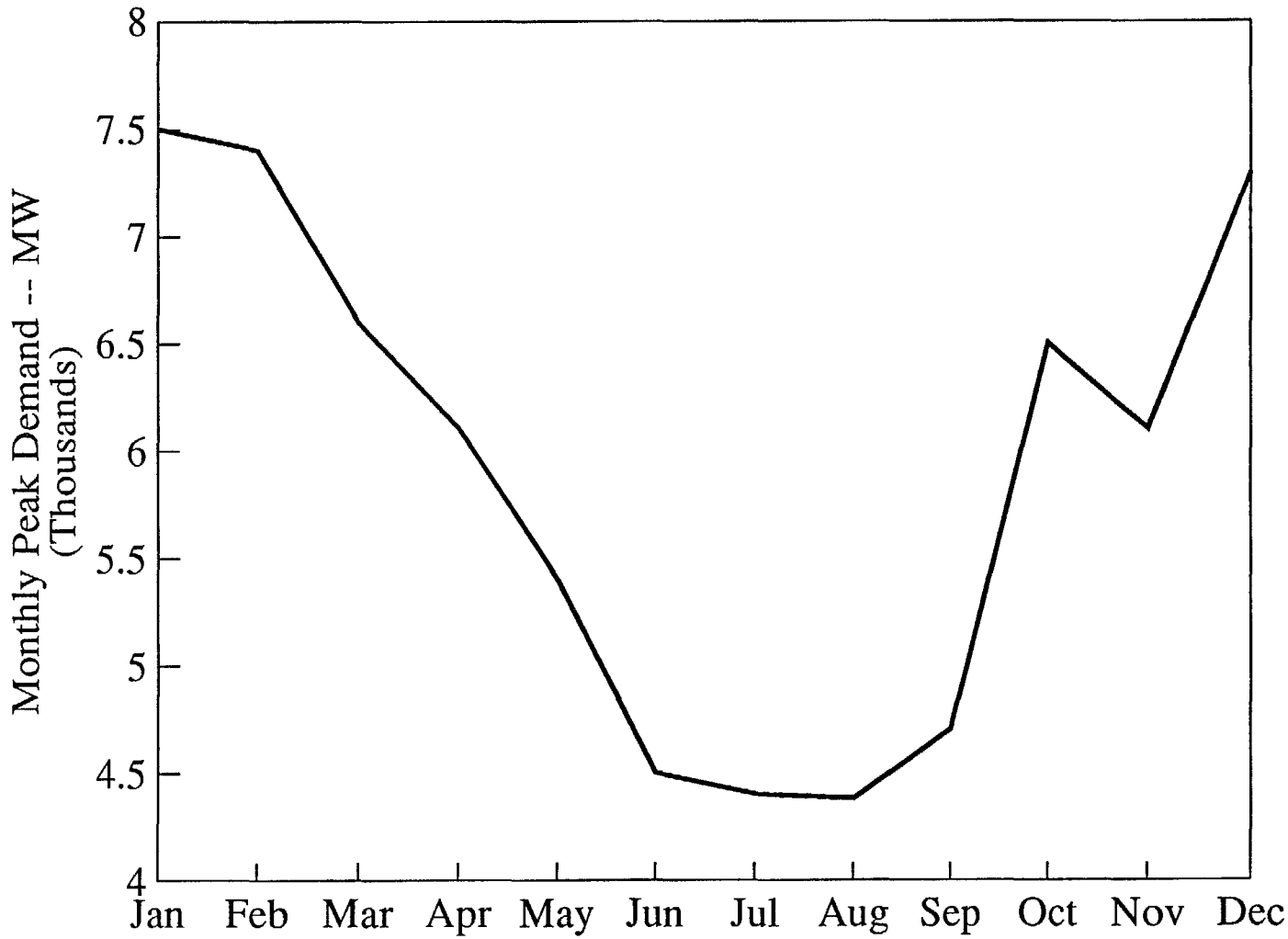
Exhibit 1-2 presents the peak demand for each month of 1991. The maximum was recorded in January (7,500 MW), and August experienced the lowest peak (4,300 MW). The difference of more than 3,000 MW is attributed to the demand for heating.

Exhibit 1-3 presents the load duration curve for the NEK system for two years, 1982 and 1991. The difference between the two curves shows that most of the reduction in demand has occurred during summer months, and that some reduction has occurred during off-peak periods in the winter.

Exhibit 1-4 shows the daily load curve for typical working days in January 1991 and July 1991. The load swing in winter is only about 13% between peak and minimum, whereas in summer it is more than 25%.

Exhibit 1-2

# Peak Demand by Month
# Bulgaria 1991




1991

Exhibit 1-3

# Load Duration Curve
# Bulgaria -- 1991 and 1982

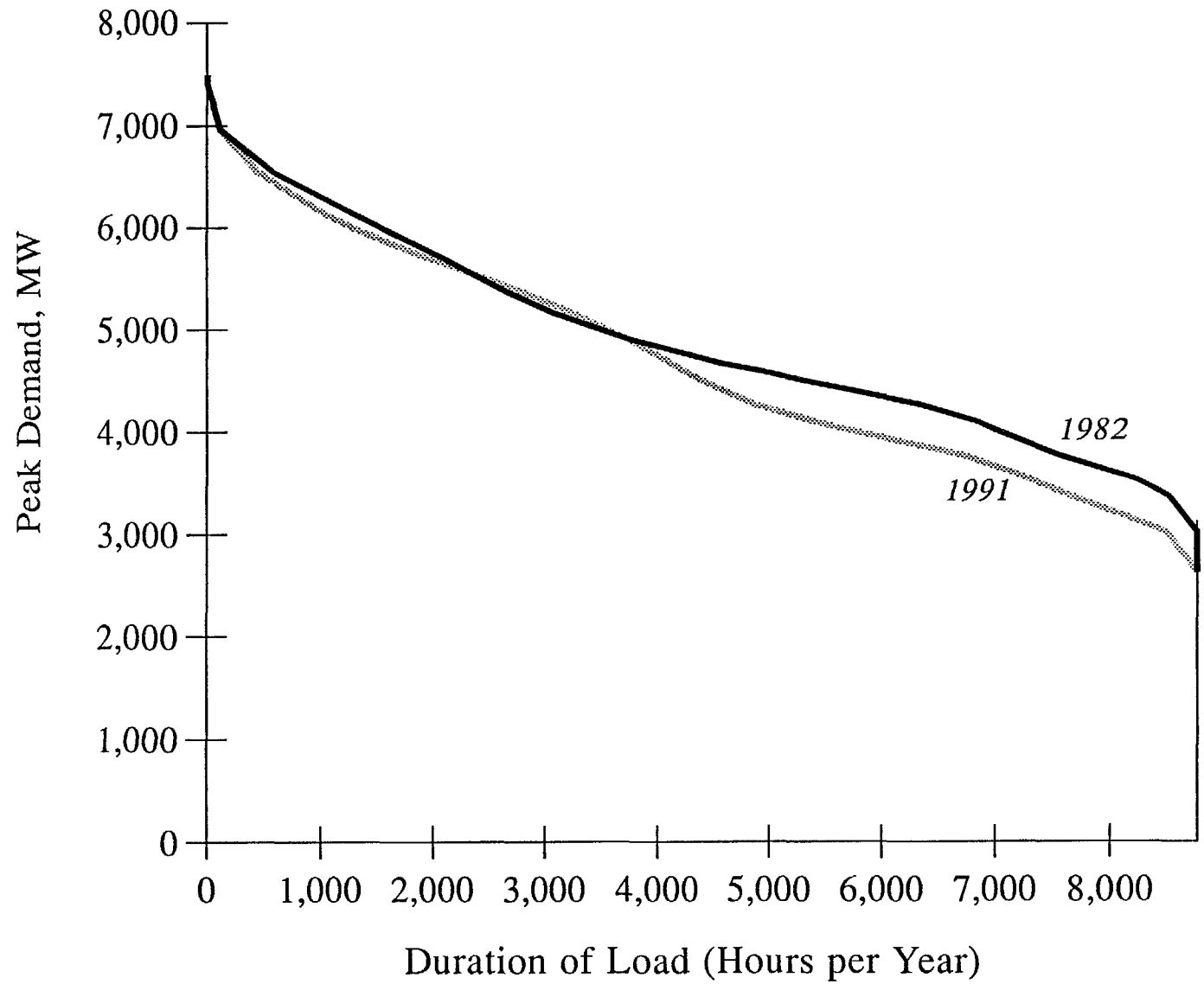



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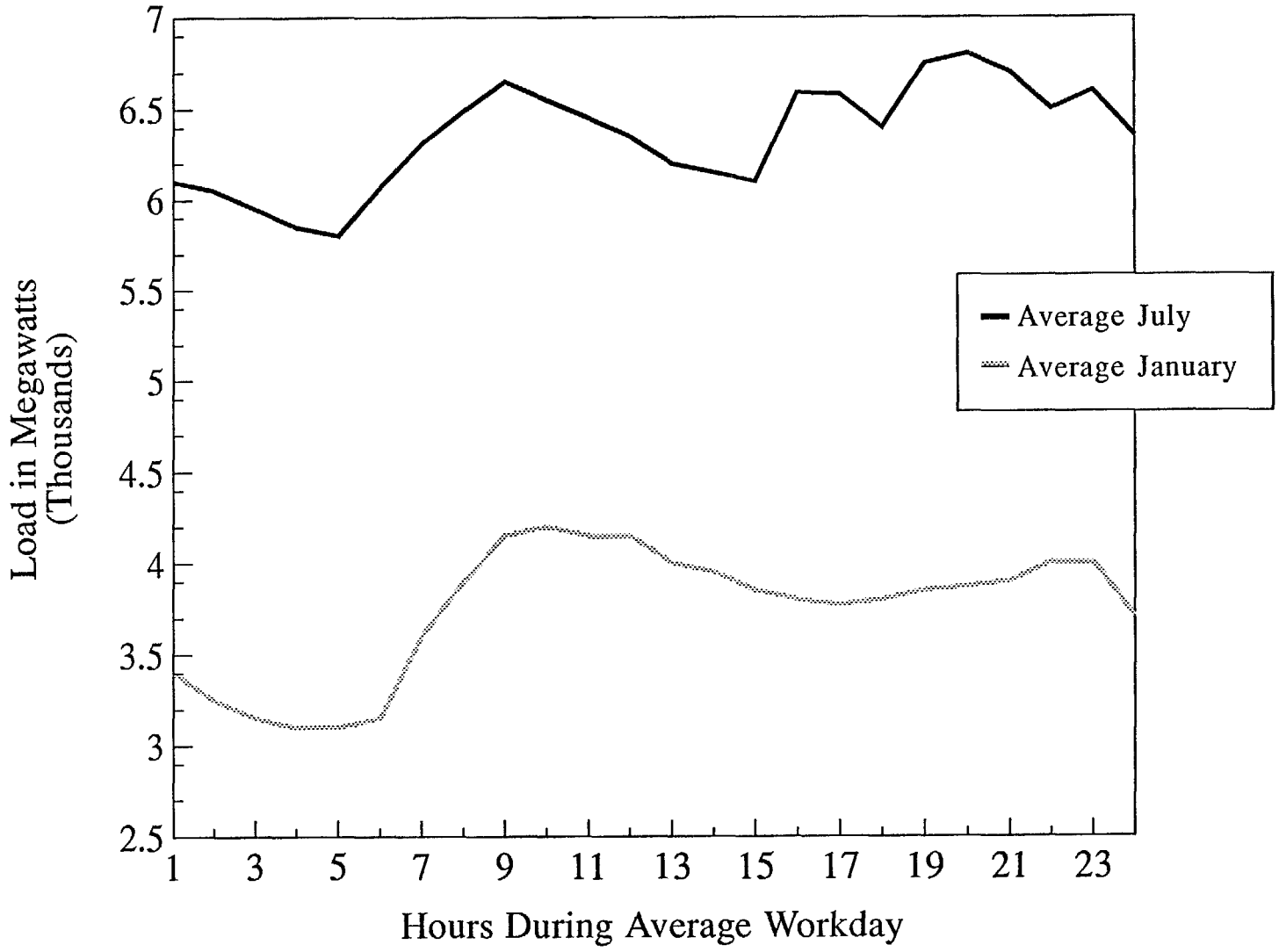
Exhibit 1-4

# Daily Load Profile - Bulgaria

## Average Day in January & July



### 1.2.1 Industrial and Commercial Sales by NEK

Industrial electric energy sales remained fairly constant during the latter part of the 1980s at 20-21,000 GWh per year through 1989. In 1990, sales decreased about 7% and in 1991, sales decreased a further 23%.

Data were provided by NEK for the breakdown of electricity consumption by industrial sector, and individually for the 106 largest electricity consumers. These data are summarized in Exhibit 1-5.

The dramatic drop in industrial electricity use in 1991 from 1990 was virtually universal across all sectors. Plants reduced their operations significantly and some shut down completely. The data indicate the greatest declines (using 1989 as a base) in the following sectors:

- chemicals (38%)
- pulp & paper (45%)
- timber (34%)
- food & beverage (25%)
- construction (30%)
- public sector buildings (34%)

### 1.2.2 Household Sales by NEK

During the decade of the 1980s, the price of electricity to households remained constant, and so, with inflation, the real price of electricity drifted downwards. No real increases in household tariffs occurred until 1992.

Referring back to Exhibit 1-1, household electricity demand increased steadily over the several years leading up to 1991. During 1991, while total electricity consumption was decreasing almost 15%, household consumption decreased by less than 1%. However, with substantial increases in tariffs, reductions in demand began in 1992, and sales were down about 8%.

## 1.3 FACTORS INFLUENCING DEMAND

Several factors influence the demand for electricity. The two primary effects are:

- *Income* - For the industrial sector, the health of the economy, both local and worldwide, determines the demand for goods and services, and in turn, this determines the demand for electricity. For households, income affects ability to buy electric appliances or even electric energy itself.

**Exhibit 1–5**
**BULGARIA**
**RECENT ELECTRICITY SALES**
**TO INDUSTRY SECTORS AND LARGEST CUSTOMERS**

| | 1987 | 1988 | 1989 | 1990 | 1991 | 1992 |
|---|---|---|---|---|---|---|
| Ferrous Metals | 2,988 | 3,029 | 2,980 | 2,869 | 2,640 | **2,481** |
| Promet (S) | | | | | 37 | 44 |
| Kremikovtsi (S) | | | | | 849 | 764 |
| Stomana | | | | | 446 | 487 |
| Other | | | | | 1,308 | 806 |
| **Non–ferrous Metals** | **1,878** | **1,906** | **1,863** | **1,777** | **1,635** | **1,537** |
| Medril Mihi | | | | | 44 | 54 |
| Chiprovech | | | | | 15 | 22 |
| Polimet | | | | | 41 | 40 |
| MDP "Elatsite" | | | | | 0 | 17 |
| GORYBSO–AD IVru | | | | | 27 | 26 |
| OTSK–OOD | | | | | 118 | 117 |
| Olovo i Tsink | | | | | 24 | 22 |
| OP "Elatsite" | | | | | 161 | 400 |
| Redki Metali | | | | | 34 | 18 |
| Medodobiven K. (S) | | | | | 152 | 260 |
| D. Blagoev (S) | | | | | 198 | 200 |
| Alumina | | | | | 35 | 34 |
| OTSM (S) | | | | | 41 | 40 |
| Other | | | | | 746 | 286 |
| **Chemicals** | **6,350** | **6,378** | **4,443** | **3,771** | **3,017** | **2,752** |
| Kaltsit (S) | | | | | 50 | 55 |
| Neftohim (S) | | | | | 195 | 116 |
| Agropolihim | | | | | 143 | 123 |
| Polimeri | | | | | 347 | 114 |
| TK "Sodi"–star | | | | | 192 | 38 |
| F "Neohim" | | | | | 207 | 175 |
| Agrabiohim | | | | | 576 | 581 |
| HIMKO | | | | | 452 | 455 |
| Yambolen | | | | | 50 | 54 |
| Plasthin | | | | | 17 | 21 |
| Lateks (S) | | | | | 10 | 7 |
| Geoson | | | | | 25 | 23 |
| Gavril Genov (S) | | | | | 14 | 13 |
| P. Karaminchev | | | | | 12 | 13 |
| Smyadovo–OOD | | | | | 11 | 5 |
| Odesos (S) | | | | | 10 | 13 |
| Antibiotik (S) | | | | | 107 | 109 |
| Other | | | | | 601 | 837 |
| **Engineering – metallic products** | | | **2,212** | **2,159** | **1,987** | **1,867** |
| Energorem. 3–D (S) | | | | | 25 | 19 |
| K–t za Traktori | | | | | 18 | 12 |
| Osam | | | | | 26 | 10 |

Exhibit 1–5
BULGARIA
RECENT ELECTRICITY SALES
TO INDUSTRY SECTORS AND LARGEST CUSTOMERS

| | 1987 | 1988 | 1989 | 1990 | 1991 | 1992 |
|---|---|---|---|---|---|---|
| Akumikar | | | | | 13 | 17 |
| Fitingi | | | | | 30 | 24 |
| LEKO–KO | | | | | 102 | 34 |
| SLZ (S) | | | | | 149 | 21 |
| ZTM–OOD (S) | | | | | 25 | 16 |
| Korabostr. –OOD | | | | | 10 | 11 |
| Madara | | | | | 45 | 21 |
| G. Dimitrov (S) | | | | | 16 | 14 |
| TKEP "6 Sept." (S) | | | | | 18 | 11 |
| ZMM–AD (S) | | | | | 14 | 15 |
| MK "VMZ" | | | | | 88 | 84 |
| Progres | | | | | 17 | 13 |
| Varn. Korabostr. (S) | | | | | 31 | 41 |
| Veslets 91 | | | | | 39 | 52 |
| KAMET (S) | | | | | 99 | 36 |
| Rekora (S) | | | | | 5 | 15 |
| Other | | | | | 1,215 | 1,400 |
| **Electrical & Electronics** | | | **817** | **700** | **686** | **648** |
| B. Kolarov | | | | | 12 | 26 |
| Eltos | | | | | 10 | 11 |
| Feromagniti | | | | | 21 | 20 |
| Svetlkna | | | | | 19 | 15 |
| Elprom–Dinamo | | | | | 14 | 9 |
| Elprom–ZEM–ad (S) | | | | | 0 | 14 |
| D S U | | | | | 29 | 17 |
| Elima | | | | | 22 | 19 |
| Elkom (S) | | | | | 9 | 12 |
| Other | | | | | 551 | 506 |
| **Building Materials** | | **1,395** | **1,305** | **1,161** | **1,068** | **1,004** |
| Beloiz. Tsiment | | | | | 88 | 55 |
| Devn. Tsiment | | | | | 120 | 103 |
| Bulkan | | | | | 33 | 37 |
| Izida | | | | | 16 | 16 |
| Pl. Tsiment | | | | | 50 | 60 |
| Zl. Panega | | | | | 84 | 89 |
| Han Asparuh (S) | | | | | 18 | 16 |
| Kaolin (S) | | | | | 8 | 18 |
| Other | | | | | 652 | 610 |
| Timber | | | 419 | 380 | 304 | 277 |
| **Pulp & paper, wood products** | | | **637** | **481** | **385** | **351** |
| Rulon–Iskar (S) | | | | | 26 | 27 |
| PHHI | | | | | 29 | 24 |
| TKTSH | | | | | 34 | 57 |
| ZMK (S) | | | | | 76 | 32 |



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**Exhibit 1–5**
**BULGARIA**
**RECENT ELECTRICITY SALES**
**TO INDUSTRY SECTORS AND LARGEST CUSTOMERS**

| | 1987 | 1988 | 1989 | 1990 | 1991 | 1992 |
|---|---|---|---|---|---|---|
| Lesil | | | | | 49 | 17 |
| St. Kirajiev (S) | | | | | 55 | 55 |
| TKHTS (S) | | | | | 31 | 13 |
| Other | | | | | 85 | 126 |
| **Glass** | | | **424** | **504** | **494** | **466** |
| Belopal | | | | | 42 | 38 |
| Kitka | | | | | 29 | 25 |
| Fayans | | | | | 24 | 26 |
| Rubin | | | | | 35 | 25 |
| Drushba | | | | | 44 | 44 |
| Kvarts | | | | | 22 | 18 |
| Diamant (S) | | | | | 21 | 21 |
| Other | | | | | 276 | 269 |
| **Textiles** | | **784** | **767** | **662** | **609** | **572** |
| Manuela | | | | | 18 | 23 |
| Dobruja | | | | | 8 | 9 |
| Sliteks | | | | | 21 | 21 |
| Vratitsa | | | | | 18 | 14 |
| Other | | | | | 543 | 505 |
| **Food & Beverage** | | **1,454** | **1,521** | **1,312** | **1,207** | **1,135** |
| N. Vaptsarov | | | | | 6 | 33 |
| Tyot. Kombinat (S) | | | | | 12 | 11 |
| MEZ "Kambana" (S) | | | | | 8 | 8 |
| SKPPPMYA (S) | | | | | 14 | 8 |
| Other | | | | | 1,167 | 1,075 |
| **Other Industries** | | | **1,047** | **1,066** | **981** | **922** |
| Bules (S) | | | | | 14 | 11 |
| Cherno More (S) | | | | | 8 | 9 |
| Construction | 1,091 | 1,139 | 994 | 896 | 740 | 696 |
| Agriculture | 1,143 | 1,094 | 1,070 | 995 | 870 | 873 |
| Transport & Communications | 1,441 | 1,489 | 1,493 | 1,483 | 1,400 | 1,392 |
| Public Sector | 4,849 | 4,629 | 4,664 | 3,610 | 3,175 | 3,061 |

INDDB.WK1



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- *Price* - Low electricity tariffs encourage greater consumption, and higher prices should lead to conservation. The structure of tariffs (for example, amount charged to large industrial customers as compared to households) is very important in determining sector demand.

Secondary effects are:

- *Structure of industry* - As the prices of energy and inputs increase, the cost of producing goods increases. Those goods that have the greatest increases in productivity or are the most energy efficient in production will tend to be relatively lower cost industries, and the demand for goods will shift towards these industries. This shift will bring about a scale effect as inefficient plants close and a substitution effect as demand is shifted to the more electricity-efficient industries.

- *Energy conservation programs* - The government can directly affect the demand for electricity through the level of its promulgation of energy conservation programs.

- *Privatization* - The government indirectly affects the use of electricity by its industrial policies. The industries that the government promotes through either subsidies or by assisting in the privatization process should become more healthy, affecting the eventual demand for electricity.

- *Commercial services* - The privatization process will also spur the development of the commercial sector, which will require electricity for lighting, cooking, refrigeration, heating, ventilation and air conditioning.

- *Weather conditions* - Bulgaria's peak demand increases by more than 3,000 MW in the winter, so a cold winter will cause an increase in demand.

- *Household formation* - Population growth and residential construction leads to the formation of new households and the creation of new customers. Since 1980, population growth has average only about 0.2% per year in Bulgaria.

- *Regional differences* - The demand for electricity varies by region, because of the concentration of industry, the size of the population, and differing weather patterns. The historical regional distribution of electricity sales is provided in Exhibit 1-6. The change in electricity use varies over time by district, with some districts increasing their share as their decreases in electricity use are less than other those of other districts.

## Exhibit 1-6
## SALES OF ELECTRICITY BY REGION (GWh)

| Year | 1985 | 1986 | 1987 | 1988 | 1989 | 1990 | 1991 |
|---|---|---|---|---|---|---|---|
| Sofia City | 5,109 | 4,935 | 5,054 | 5,193 | 5,150 | 4,694 | 4,025 |
| Sofia District | 4,126 | 4,278 | 4,564 | 4,653 | 4,649 | 4,308 | 3,497 |
| Pleven | 4,723 | 4,671 | 5,025 | 5,049 | 4,773 | 4,914 | 4,199 |
| G. Oryahvitza | 4,069 | 3,926 | 4,196 | 4,373 | 4,319 | 4,096 | 3,493 |
| Varna | 4,743 | 4,614 | 4,523 | 4,694 | 4,626 | 4,335 | 3,629 |
| St. Zagora | 5,398 | 5,506 | 5,751 | 6,063 | 6,030 | 5,666 | 4,979 |
| Plovdiv | 6,269 | 6,244 | 6,583 | 6,671 | 6,723 | 6,494 | 5,579 |
| Total | 34,437 | 34,174 | 35,696 | 36,696 | 36,270 | 34,507 | 29,401 |

## 2. RESULTS OF INDUSTRIAL ENERGY SURVEY

The largest industrial consumers in Bulgaria are judged to be at the greatest risk of losing their market, and their ability to cope with this dislocation will determine their survival, and thus their demand for electricity. To develop a better understanding of the conditions at these large consumers, a survey of the NEK's 106 largest electrical consumers was commissioned by RCG/Hagler Bailly as part of the project. Hagler Bailly subcontracted with Dimitar Baev - DBC, a private Bulgarian firm, to carry out the work.

### 2.1 OBJECTIVE

The objective of the survey was to poll the 106 largest industrial electricity consumers with respect to their electricity consumption, business and economic activity, electrical generation at the facility (if any) and energy efficiency.

### 2.2 ACTIVITIES

The project included the following tasks:

1) An English draft survey instrument was developed by Hagler, Bailly, and subsequently a Bulgarian version of the survey questionnaire by DBC, taking into account locally-accepted survey techniques by means of network of interviewers, as well as the recommendations of the experts from the Committee of Energy.

2) A test run of the survey was made in 7 enterprises in Sofia to verify that the survey instrument was acceptable. Based on the results, Hagler, Bailly determined that a two-stage methodology was required.

3) The survey instrument was distributed to the 106 largest electric consumers, and personal visits were made to each site in an attempt to achieve a high response rate to the survey.

4) For those who agreed to participate, on-site interviews were done by a nationwide network of interviewers (comprising over 20 interviewers) over the period November - December 1992.

5) A follow-up survey was conducted in the cooperating industries in December 1992 -

January 1993 to obtain more quantitative data on energy consumption and production, and to evaluate the plant's attitudes toward energy conservation.

6) A data base was created containing the data from all the responses of the questionnaires.

7) Statistical analysis of the results was carried out by DBC.

8) Reports were prepared for both the main and the follow-up surveys by DBC, and provided to Hagler, Bailly and Committee of Energy.

## 2.3 DESCRIPTION OF THE SURVEY

### 2.3.1 Conditions in which the survey was conducted

The survey was influenced by number of factors, characteristic of the state of the Bulgarian economy and industry:

- deep economic recession, and decrease of the production;
- loss of most of Bulgaria's traditional markets and trading partners;
- de-monopolization and disintegration of old production structures;
- considerable increase in the percentage of unemployment;
- slow rates of the progress of restructuring of the economy and privatization;
- substantial decrease of state subsidies and increase of the debts of the enterprises.

During this period, Bulgaria was faced with particularly acute energy problems, including power outages. The period of the survey also coincided with government decisions for substantial increases in electricity tariffs and other energy prices.

Finally, another important fact should be taken into account - that in Bulgaria there is no tradition for conducting such surveys in industry.

### 2.3.2 Survey interview techniques

The enterprises, subject to the survey are situated over the whole territory of Bulgaria, most of them being some distance from the large cities. From the point of view of the number of

questions as well as from the point of view of it's content, the study could be classified as technically complicated.

The officials which took part in the filling up of the questionnaires, were as follows:

- Top managers of the enterprises (general directors, executive directors);
- Deputy directors, responsible for the economics or production;
- Chief power engineering specialists, or Heads of departments "Power engineering";
- Heads of departments "Planning and Economics";
- Experts and specialists;

As a rule several of them took part successively in the responding of the questionnaires. The mean time to receive the full response was 15-20 days. During that time it was necessary for the interviewers to visit the enterprise several times in order to stimulate a response to the questionnaires.

From the total of 106 questionnaires send, 61 responded (57% rate), and 35 of these responded to the follow-up survey (33% response rate to full survey). In certain sectors of industry as coal mining, iron and steel, timber, construction and other branches the response rate was 100%. Of those who did not respond, some of the more important reasons were the following:

- The enterprises refuse in principle to accept questionnaires, because of the following motives:

  -- the questions represent firm's secrets;
  -- there are apprehensions of misuse of the information against the interests of the enterprise;
  -- essential structural and personnel changes are in progress;
  -- it is considered a priori that this is a pure waste of time.

  This group includes about 20 % of those who didn't answer.

- Enterprises which accepted the questionnaires, but didn't respond because of the following reasons:

  -- responding to the survey is of low priority, compared with the current operative tasks;
  -- it is impossible to create organization for joint completion of the

questionnaires;
- -- fear of responsibility;
- -- during the progress of the filling up it is realized that more effort is necessary than originally considered;
- -- the questionnaire is left without control to somebody's working place, etc.

This group is the largest and includes about 75% of those who didn't answer.

- The enterprise said that the questionnaires were completed and sent to the interviewers by post, but were lost. This is about 5% of those not responding.

## 2.4 SUMMARY OF THE RESULTS

### 2.4.1 Business and operating conditions

Exhibit 2-1 shows the results of part 1 of the survey, which was intended to summarize business conditions and operating characteristics. The exhibit shows each survey item and a summary of the responses, by percentage. The percentages do not add up to 100% in those cases in which one or more respondents did not answer an item or judged two choices equal.

As shown in Exhibit 2-1:

- Employment is in decline, and is expected to decline further in 48% of the sites;

- Plant capacity utilization declined significantly in 1991 (number of plants operating at 50% capacity or less went from 11% to 28%) and slightly in 1992 (35% of plants at 50% capacity or less), the largest declines were in the engineered products and chemicals/petroleum sectors;

- Capacity utilization is forecast to improve slightly in 1993 (only 20% at 50% capacity or less, with the food industry particularly optimistic);

- The principal factor required for recovery:

  - -- new markets (mentioned by 57%);
  - -- better management, efficiency, productivity or quality (20%);
  - -- new technology (14%);
  - -- supply of raw materials (14%);
  - -- higher prices (6%);
  - -- economic recovery (6%).

- Half of the plants have made significant investments in the past two years, and

43% expect to make significant investments in 1993 (metallurgy industries expect to invest, pulp & paper does not);

- Privatization is expected in the next two years by only 20% of the plants;
- Backlogs of manufacturing orders are fairly good, and inventories are not excessive;
- Most plants work multiple shifts - 17% have changed working hours since 1990, and 9% expect to change in 1993;
- Hours of operation correspond with NEK peaks, and 59% work 24 hours per day;
- Solving manufacturing problems (such as marketing, raw material supply, quality, and productivity) are judged higher priorities than energy cost reduction;
- Among energy costs, electricity was the highest priority.

EXHIBIT 2–1
BULGARIA
SURVEY OF LARGEST ELECTRICAL CONSUMERS
DECEMBER 1992 BY ET "DIMITAR BAEV – DBC"

PART 1 – SUMMARY OF OPERATIONS AND BUSINESS CONDITIONS

| HOW MANY NUMBER OF EMPLOYEES AT THIS FACILITY? | | | |
|---|---|---|---|
| less than 1000 | 1000–2000 | 2000–5000 | over 5000 |
| 38% | 32% | 18% | 5% |

| HOW HAS THE NUMBER OF EMPLOYEES CHANGED IN THE LAST YEAR? | | | | |
|---|---|---|---|---|
| | | reduced by: | reduced by: | reduced by: |
| same | increased | 5–10% | 10–20% | more than 20% |
| 21% | 9% | 39% | 11% | 13% |

| HOW DO YOU EXPECT THE NUMBER OF EMPLOYEES TO CHANGE OVER THE NEXT YEAR? | | | | |
|---|---|---|---|---|
| | | reduced by: | reduced by: | reduced by: |
| same | increased | 5–10% | 10–20% | more than 20% |
| 52% | 7% | 23% | 9% | 5% |

| WHAT IS THE BUSINESS OUTLOOK FOR YOUR INDUSTRIAL SECTOR? | | |
|---|---|---|
| optimistic | pessimistic | not clear |
| 46% | 2% | 46% |

| APPROXIMATELY WHAT PERCENT OF MAXIMUM CAPACITY DID YOUR ENTERPRISE PRODUCE? | | | | |
|---|---|---|---|---|
| Year | less than 25% | 25–50% | 51–75% | 76–100% |
| 1990 | 4% | 7% | 27% | 48% |
| 1991 | 7% | 21% | 41% | 18% |
| 1992 | 5% | 30% | 43% | 11% |

| APPROXIMATELY WHAT PERCENT OF MAXIMUM CAPACITY DOES YOUR ENTERPRISE EXPECT TO PRODUCE IN 1993? | | | |
|---|---|---|---|
| less than 25% | 25–50% | 51–75% | 76–100% |
| 0% | 20% | 41% | 21% |

| HAS YOUR ENTERPRISE MADE ANY SIGNIFICANT CAPITAL INVESTMENTS? | | |
|---|---|---|
| | Yes | No |
| In the last 2 years | 50% | 43% |
| In the last 6 months | 25% | 61% |

EXHIBIT 2–1
BULGARIA
SURVEY OF LARGEST ELECTRICAL CONSUMERS
DECEMBER 1992 BY ET "DIMITAR BAEV – DBC"

PART 1 – SUMMARY OF OPERATIONS AND BUSINESS CONDITIONS

| DOES YOUR ENTERPRISE PLAN TO MAKE SIGNIFICANT INVESTMENTS IN THE NEXT YEAR? | |
|---|---|
| Yes | No |
| 43% | 48% |

| WHEN DO YOU ANTICIPATE THAT THIS ENTERPRISE WILL BE PRIVATIZED? | | | | |
|---|---|---|---|---|
| already done | 0–12 months | 12–24 months | more than 24 months | not likely ever |
| 0% | 11% | 9% | 36% | 36% |

| APPROXIMATELY HOW LONG IS YOUR ENTERPRISE'S BACKLOG OF ORDERS? | | | | | |
|---|---|---|---|---|---|
| months of production at current production rate | | | | | |
| less than 1 | 1 – 2 | 2 – 4 | 4 – 6 | 6 – 9 | 9 – 12 |
| 11% | 20% | 11% | 6% | 11% | 6% |

| APPROXIMATELY HOW LARGE IS YOUR ENTERPRISE'S INVENTORY OF FINISHED PRODUCTS? | | | | | |
|---|---|---|---|---|---|
| months of production at current production rate | | | | | |
| less than 1 | 1 – 2 | 2 – 4 | 4 – 6 | 6 – 9 | 9 – 12 |
| 23% | 17% | 6% | 0% | 0% | 3% |

| HOW DOES THE ENTERPRISE OPERATE DURING THE DAY? | | |
|---|---|---|
| 24 hours/day | 2 shifts | 1 shift |
| 59% | 29% | 13% |

| HOW MANY HOURS PER WEEK DOES THE MAIN PRODUCTION PROCESS OPERATE? | | | | | | |
|---|---|---|---|---|---|---|
| less than 24 | 24–48 | 48–72 | 72–96 | 96–120 | 120–144 | 144–168 |
| 9% | 17% | 9% | 12% | 3% | 9% | 41% |

EXHIBIT 2-1
BULGARIA
SURVEY OF LARGEST ELECTRICAL CONSUMERS
DECEMBER 1992 BY ET "DIMITAR BAEV – DBC"

PART 1 – SUMMARY OF OPERATIONS AND BUSINESS CONDITIONS

WHAT ARE THE HOURS OF OPERATION OF THE PRODUCTION PROCESS AT YOUR ENTERPRISE?

| hours of operation | Monday | Tuesday | Wednesday | Thursday | Friday | Saturday | Sunday |
|---|---|---|---|---|---|---|---|
| 0 – 1 | 62% | 65% | 65% | 65% | 65% | 59% | 56% |
| 1 – 2 | 62% | 65% | 65% | 65% | 65% | 59% | 56% |
| 2 – 3 | 62% | 65% | 65% | 65% | 65% | 59% | 56% |
| 3 – 4 | 62% | 65% | 65% | 65% | 65% | 59% | 56% |
| 4 – 5 | 62% | 65% | 65% | 65% | 65% | 59% | 56% |
| 5 – 6 | 68% | 71% | 71% | 71% | 71% | 62% | 59% |
| 6 – 7 | 76% | 76% | 76% | 76% | 76% | 65% | 65% |
| 7 – 8 | 82% | 82% | 82% | 82% | 82% | 68% | 68% |
| 8 – 9 | 100% | 100% | 100% | 100% | 100% | 74% | 68% |
| 9 – 10 | 100% | 100% | 100% | 100% | 100% | 74% | 68% |
| 10 – 11 | 100% | 100% | 100% | 100% | 100% | 74% | 68% |
| 11 – 12 | 100% | 100% | 100% | 100% | 100% | 74% | 68% |
| 12 – 13 | 100% | 100% | 100% | 100% | 100% | 74% | 68% |
| 13 – 14 | 100% | 100% | 100% | 100% | 100% | 71% | 68% |
| 14 – 15 | 100% | 100% | 100% | 100% | 100% | 71% | 68% |
| 15 – 16 | 100% | 100% | 100% | 100% | 100% | 71% | 68% |
| 16 – 17 | 91% | 91% | 91% | 91% | 91% | 71% | 68% |
| 17 – 18 | 79% | 79% | 79% | 79% | 79% | 65% | 65% |
| 18 – 19 | 79% | 79% | 79% | 79% | 79% | 65% | 65% |
| 19 – 20 | 79% | 79% | 79% | 79% | 79% | 65% | 65% |
| 20 – 21 | 79% | 79% | 79% | 79% | 79% | 65% | 65% |
| 21 – 22 | 76% | 76% | 76% | 76% | 76% | 62% | 62% |
| 22 – 23 | 74% | 74% | 74% | 74% | 74% | 62% | 62% |
| 23 – 24 | 71% | 71% | 71% | 71% | 71% | 62% | 62% |

HAVE THERE BEEN ANY CHANGES TO THESE HOURS SINCE 1990?

| Yes | No |
|---|---|
| 17% | 77% |

DO YOU EXPECT ANY CHANGES TO THESE HOURS IN 1993?

| Yes | No |
|---|---|
| 9% | 86% |

EXHIBIT 2–1
BULGARIA
SURVEY OF LARGEST ELECTRICAL CONSUMERS
DECEMBER 1992 BY ET "DIMITAR BAEV – DBC"

PART 1 – SUMMARY OF OPERATIONS AND BUSINESS CONDITIONS

WHAT ARE NOW THE SHORT–TERM PRIORITIES IN YOUR ENTERPRISE?

| | Percentage who ranked it (5 is top priority) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Description of the problem | 5 | 4 | 3 | 2 | 1 | 0 | Score | Rank |
| Finding a way to sell more of our finished products | 63% | 14% | 6% | 3% | 3% | 11% | 3.97 | 1 |
| Obtaining reliable sources of raw materials | 34% | 20% | 3% | 11% | 6% | 26% | 2.89 | 2 |
| Reducing the cost of production, not including energy | 26% | 14% | 23% | 11% | 6% | 20% | 2.83 | 3 |
| Improving the quality of our products | 20% | 17% | 17% | 9% | 0% | 37% | 2.37 | 4 |
| Reducing the cost of electric energy | 17% | 20% | 14% | 9% | 3% | 37% | 2.29 | 5 |
| Managing people and improving labor productivity | 20% | 6% | 26% | 9% | 9% | 31% | 2.26 | 6 |
| Maintaining our equipment, reducing break–downs | 14% | 14% | 26% | 3% | 3% | 40% | 2.14 | 7 |
| Reducing the cost of fuel energy | 14% | 17% | 11% | 14% | 6% | 37% | 2.09 | 8 |
| Reducing pollution, improving ecology | 17% | 11% | 11% | 17% | 6% | 37% | 2.06 | 9 |
| Obtaining reliable sources of electric energy | 9% | 11% | 20% | 11% | 3% | 46% | 1.74 | 10 |
| Dealing with inefficient government bureacracy | 11% | 6% | 23% | 9% | 0% | 51% | 1.66 | 11 |
| Reducing the cost of heat energy | 6% | 17% | 17% | 6% | 3% | 51% | 1.63 | 12 |
| Privatizing our plant | 9% | 11% | 23% | 0% | 3% | 54% | 1.60 | 13 |
| Changing our plant to produce different products | 6% | 11% | 14% | 11% | 6% | 51% | 1.46 | 14 |
| Obtaining reliable sources of heat energy | 14% | 6% | 0% | 11% | 6% | 63% | 1.23 | 15 |
| Reducing operations to meet the market conditions | 3% | 6% | 17% | 11% | 3% | 60% | 1.14 | 16 |
| Obtainining reliable sources of fuel energy | 0% | 14% | 9% | 6% | 11% | 60% | 1.06 | 17 |
| Other | 3% | 0% | 0% | 3% | 0% | 94% | 0.20 | 18 |

### 2.4.2 Current and projected electricity usage

Exhibit 2-2 shows the results of part 2 of the survey, which concerned electricity usage. Again, the exhibit shows each survey item and a summary of the responses, by percentage. The percentages do not add up to 100% in those cases in which one or more respondents did not answer an item.

As shown in Exhibit 2-2:

- 83% of the sites have a load of 10 MW or more;
- 1992 electricity consumption was reduced from 1991 in 46% of the plants;
- 1992 reductions were significant (10% or more) in 31% of the plants, and very large (20% or more) in 20% of the plants;
- 1993 electricity consumption and peak usage is forecast to be the same as 1992, or higher, in 91% of the plants;
- Peak demand (MW) seems be about the same as day MW;
- Reductions in peak demand have been significantly less than reductions in energy consumption, and this trend is expected to continue;
- The expected changes in electricity consumption are well correlated with the expected changes in production;

EXHIBIT 2–2
BULGARIA
SURVEY OF LARGEST ELECTRICAL CONSUMERS
DECEMBER 1992 BY ET "DIMITAR BAEV – DBC"

PART 2 – CURRENT AND PROJECTED ELECTRIC ENERGY USAGE

WHAT IS THE ELECTRIC ENERGY CONSUMPTION FOR YOUR ENTERPRISE FOR 1992?

| | Gigawatt–hours (GWh): | | | | |
|---|---|---|---|---|---|
| Period: | less than 2 | 2 – 5 | 5 – 10 | 10 – 20 | 20 or more |
| peak GWh | 9% | 51% | 17% | 9% | 11% |
| day GWh | 3% | 14% | 34% | 23% | 23% |
| night GWh | 14% | 40% | 9% | 20% | 14% |
| TOTAL GWh | 3% | 0% | 11% | 40% | 43% |

HOW IS YOUR ELECTRIC ENERGY CONSUMPTION DISTRIBUTED FOR 1992?

| Peak energy | Day energy | Night energy |
|---|---|---|
| 22% | 45% | 32% |

HOW HAS THE TOTAL ELECTRIC ENERGY CONSUMPTION CHANGED IN COMPARISON WITH 1991?

| CHANGE | the same | increased by... | decreased by... |
|---|---|---|---|
| 0 | 31% | | |
| 1–5% | | 6% | 14% |
| 5–10% | | 0% | 0% |
| 10–20% | | 6% | 11% |
| 20–50% | | 9% | 17% |
| > 50% | | 0% | 3% |
| TOTAL | 31% | 20% | 46% |

HOW DO YOU EXPECT THE TOTAL ELECTRIC ENERGY CONSUMPTION TO CHANGE IN 1993, COMPARED WITH 1992?

| CHANGE | the same | to increase by... | to decrease... |
|---|---|---|---|
| 0 | 51% | | |
| 1–5% | | 11% | 0% |
| 5–10% | | 3% | 0% |
| 10–20% | | 6% | 3% |
| 20–50% | | 11% | 6% |
| > 50% | | 9% | 0% |
| TOTAL | 51% | 40% | 9% |

EXHIBIT 2-2
BULGARIA
SURVEY OF LARGEST ELECTRICAL CONSUMERS
DECEMBER 1992 BY ET "DIMITAR BAEV – DBC"

PART 2 – CURRENT AND PROJECTED ELECTRIC ENERGY USAGE

HOW DID THE ENERGY CONSUMPTION DURING PEAK HOURS CHANGE IN 1992, COMPARED WITH 1991?

| CHANGE | the same | increased by... | decreased by... |
|---|---|---|---|
| 0 | 29% | | |
| 1–5% | | 9% | 0% |
| 5–10% | | 9% | 3% |
| 10–20% | | 9% | 6% |
| 20–50% | | 14% | 14% |
| > 50% | | 6% | 3% |
| TOTAL | 29% | 47% | 26% |

HOW DO YOU EXPECT THE ENERGY CONSUMPTION DURING PEAK HOURS TO CHANGE IN 1993, COMPARED WITH 1992?

| CHANGE | the same | to increase by... | to decrease by... |
|---|---|---|---|
| 0 | 51% | | |
| 1–5% | | 9% | 0% |
| 5–10% | | 6% | 0% |
| 10–20% | | 3% | 6% |
| 20–50% | | 20% | 0% |
| > 50% | | 3% | 0% |
| TOTAL | 51% | 41% | 6% |

CORRELATION OF RESPONSES TO QUESTIONS ON ENERGY USAGE AND PRODUCTION:
HOW DO YOU EXPECT THE LEVEL OF PRODUCTION OUTPUT TO CHANGE IN 1993?
HOW DO YOU EXPECT THE TOTAL ELECTRIC ENERGY CONSUMPTION TO CHANGE IN 1993?

| | Electric energy consumption: | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Production Output: | the same | up 1–10% | up 10–20% | up > 20% | down 1–10% | down 10–20% | down > 20% | TOTAL |
| the same | 73% | 9% | 9% | 9% | 0% | 0% | 0% | 31% |
| up 1–10% | 33% | 33% | 17% | 17% | 0% | 0% | 0% | 17% |
| up 10–20% | 57% | 14% | 0% | 14% | 0% | 0% | 14% | 20% |
| up more than 20% | 29% | 0% | 0% | 57% | 0% | 0% | 14% | 20% |
| down 1–10% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% |
| down 10–20% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% |
| down more than 20% | 0% | 50% | 0% | 0% | 0% | 50% | 0% | 6% |
| TOTAL | 51% | 14% | 6% | 20% | 0% | 3% | 6% | |

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EXHIBIT 2–2
BULGARIA
SURVEY OF LARGEST ELECTRICAL CONSUMERS
DECEMBER 1992 BY ET "DIMITAR BAEV – DBC"

PART 2 – CURRENT AND PROJECTED ELECTRIC ENERGY USAGE

WHAT IS THE MAXIMUM ELECTRIC POWER DEMAND FOR YOUR ENTERPRISE FOR 1992?

| | Megawatts: | | | | |
|---|---|---|---|---|---|
| Period: | 0 – 5 | 5 – 10 | 10 – 20 | 20 – 50 | 50 or more |
| peak MW | 29% | 39% | 6% | 6% | 6% |
| day MW | 32% | 32% | 10% | 6% | 3% |
| night MW | 42% | 23% | 10% | 6% | 3% |

HOW DID THE MAXIMUM DEMAND (MW) CHANGE IN 1992, COMPARED WITH 1991?

| CHANGE | the same | increased by... | decreased by... |
|---|---|---|---|
| 0 | 51% | | |
| 1–5% | | 3% | 0% |
| 5–10% | | 3% | 3% |
| 10–20% | | 6% | 9% |
| 20–50% | | 6% | 14% |
| > 50% | | 0% | 0% |
| TOTAL | 51% | 18% | 26% |

HOW DO YOU EXPECT THE MAXIMUM DEMAND (MW) TO CHANGE IN 1993, COMPARED WITH 1992?

| CHANGE | the same | to increase by... | to decrease by... |
|---|---|---|---|
| 0 | 63% | | |
| 1–5% | | 6% | 0% |
| 5–10% | | 3% | 0% |
| 10–20% | | 9% | 3% |
| 20–50% | | 11% | 3% |
| > 50% | | 0% | 0% |
| TOTAL | 63% | 29% | 6% |

EXHIBIT 2–2
BULGARIA
SURVEY OF LARGEST ELECTRICAL CONSUMERS
DECEMBER 1992 BY ET "DIMITAR BAEV – DBC"

PART 2 – CURRENT AND PROJECTED ELECTRIC ENERGY USAGE

WHAT IS YOUR ESTIMATED COST FOR PURCHASED ENERGY 1992?
MILLIONS OF LEVA

| | 0–5 | 5–10 | 10–20 | 20–50 | 50–100 | more than 100 | no answer |
|---|---|---|---|---|---|---|---|
| Electricity | 3% | 23% | 23% | 17% | 6% | 6% | 23% |
| Heat | 6% | 9% | 0% | 3% | 0% | 0% | 83% |
| Gas | 9% | 6% | 9% | 3% | 0% | 3% | 71% |
| Oil | 14% | 6% | 14% | 3% | 6% | 3% | 54% |
| Coal | 14% | 0% | 0% | 3% | 0% | 0% | 83% |

### 2.4.3 Equipment installed for electricity generation and use

Exhibit 2-3 shows the results of part 3 of the survey, which concerned equipment available for power generation, and principal electricity using equipment. Again, the exhibit shows each survey item and a summary of the responses, by percentage. The percentages do not add up to 100% in those cases in which one or more respondents did not answer an item.

As shown in Exhibit 2-3:

- Only six of the plants responding have a generator, of these three are in the chemicals and petroleum sector, two in non-ferrous metals and one in glass;

- Of those six that have a generator, two do not operate regularly, but probably could do so;

- Among those six that have a generator, only half felt that the purchase price of power paid by NEK is too low;

- Among those six that have a generator, the following reasons were given for not increasing the output:

  -- three (50%) said they were at their technical potential;
  -- one said because of the reduced production rate;
  -- one said because of low electricity prices;
  -- one said because of lack of fuel.

- Among those that do not have a generator, only 2% considered it possible to install one (25% no answer or did not know);

- Motors driving pumps, fans, compressors, and other equipment were cited as primary loads by 77% of the respondents;

- Less than half of the plants use efficient lighting systems (sodium vapor, metal halide, or compact fluorescent).

- For the specific process equipment identified (some of which are relevant only to specific industrial sectors), the following totals were developed:

| | | |
|---|---|---|
| -- | electrolysis (chemicals) | 27 MW |
| -- | heat treatment (metals) | 25 MW |
| -- | rolling mills (metals) | 24 MW |
| -- | compressors | 20 MW |
| -- | electric furnaces (metals) | 18 MW |



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| | | |
|---|---|---|
| -- | water pumps | 16 MW |
| -- | catalytic cracking (petroleum) | 15 MW |
| -- | motors for other uses | 15 MW |
| -- | machine tools (engineered products) | 11 MW |
| -- | fans | 10 MW |



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EXHIBIT 2–3
BULGARIA
SURVEY OF LARGEST ELECTRICAL CONSUMERS
DECEMBER 1992 BY ET "DIMITAR BAEV – DBC"

PART 3 – EQUIPMENT INSTALLED FOR ELECTRICITY GENERATION AND USE

| IS THERE AN ELECTRIC GENERATOR AT THIS FACILITY? | |
|---|---|
| Yes | No |
| 11% | 88% |

| IF SO, DOES THE GENERATOR OPERATE REGULARLY? | |
|---|---|
| Yes | No |
| 67% | 33% |

| (FOR THOSE WHO HAVE A GENERATOR) IS THE PRICE PAID BY NEK FOR PURCHASED POWER TOO LOW? | |
|---|---|
| Yes | No |
| 50% | 50% |

| IS THERE A POSSIBILITY OF INCREASING THE OUTPUT OF YOUR EXISTING GENERATOR? | |
|---|---|
| Yes | No |
| 33% | 67% |

| IS THERE A SIGNIFICANT REQUIREMENT FOR STEAM OR HOT WATER AT YOUR FACILITY? | |
|---|---|
| Yes | No |
| 71% | 14% |

| IF YOU DO NOT HAVE A GENERATOR, IS IT POSSIBLE TO INSTALL ONE? | |
|---|---|
| Yes | No |
| 2% | 73% |

| WHAT ARE THE PRIMARY CONSUMERS OF ELECTRIC ENERGY IN YOUR ENTERPRISE? | |
|---|---|
| | Mentioned by: |
| Motors driving pumps, fans, compressors | 77% |
| Lighting | 61% |
| Electric heating, furnaces, boilers | 52% |
| Welding | 34% |
| Machine tools, metal working | 25% |
| Electrochemical processes | 14% |
| Refrigeration | 11% |
| Other | 7% |

EXHIBIT 2–3
BULGARIA
SURVEY OF LARGEST ELECTRICAL CONSUMERS
DECEMBER 1992 BY ET "DIMITAR BAEV – DBC"

PART 3 – EQUIPMENT INSTALLED FOR ELECTRICITY GENERATION AND USE

| WHAT TYPES OF LIGHTS ARE USED AT YOUR ENTERPRISE? | Mentioned by: |
|---|---|
| Fluorescent | 89% |
| Incandescent | 86% |
| Mercury vapor | 75% |
| Sodium vapor | 45% |
| Metal halide | 27% |
| Compact fluorescent | 14% |
| Other | 0% |

### 2.4.4 Energy conservation experience, opportunities, and attitudes

Exhibit 2-4 shows the results of part 4 of the survey, which concerned energy conservation. Again, the exhibit shows each survey item and a summary of the responses, by percentage. The percentages do not add up to 100% in those cases in which one or more respondents did not answer an item.

As shown in Exhibit 2-4:

- Some 13% of plants could curtail usage during peak periods a significant amount, and another 50% could reduce slightly;

- Some 77% are interested in pursuing energy conservation opportunities in their plant;

- 69% of the respondents are aware of ideas to improve energy efficiency, the measures could be grouped in the following way:

  -- expedient technological changes and improvements (65% of respondents);
  -- improvements in lighting systems and controls (20%);
  -- correct operations of production processes, such as loading of equipment and coordination of energy consumers (20%);
  -- measures for improvement of cos Φ (power factor) (9%);

- The reasons why these improvements have not yet been implemented are:

  -- lack or scarcity of funds, finances (53% of respondents);
  -- production process limitations, such as continuous operations (25%);
  -- lack of incentives, existing energy prices (9%);
  -- lack of suitable organization (6%);
  -- lack of suitable projects (6%);

- About half the plants are willing to invest in energy efficiency projects, including borrowing from a bank if necessary;

- Energy audits have been conducted in 50% of the enterprises:

  -- 58% of audits were conducted by external organizations (institutes and design organizations in energetics and automation),
  -- 27% were conducted by specialists of the enterprises themselves,
  -- 15% were joint studies by external organizations and specialists from the enterprise.



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- Of the plants that had energy audits, 6% were completely satisfied with the results, 62% found the audits to be partially satisfactory, and 28% found the audit to be useless;

- 70% of the plants would be willing to participate in an energy audit program financed by COE or NEK, and 14% refuse;

- 42% of the plants would be willing to hire an energy auditor (and about one-quarter of these had already done so);

- Only 14% of the plants were aware of any energy efficiency activities in Bulgaria by Western experts.

EXHIBIT 2–4
BULGARIA
SURVEY OF LARGEST ELECTRICAL CONSUMERS
DECEMBER 1992 BY ET "DIMITAR BAEV – DBC"

PART 4 – ENERGY CONSERVATION EXPERIENCE, OPPORTUNITIES AND ATTITUDES

| COULD THE ENTERPRISE CURTAIL ALL OR PART OF ITS ELECTRICAL USE DURING PEAK PERIODS? | | |
|---|---|---|
| Yes, significant amount | Yes, a little | None at all |
| 13% | 50% | 34% |

| COULD THE ENTERPRISE SWITCH SOME OF ITS ELECTRICAL USAGE TO FUELS? | | |
|---|---|---|
| Yes, significant amount | Yes, a little | None at all |
| 13% | 20% | 68% |

| DO YOU KNOW OR EXPECT THAT THERE ARE OTHER ENERGY EFFICIENCY MEASURES APPLICABLE TO YOUR FACILITY? | | |
|---|---|---|
| Yes, significant amount | Yes, a little | None at all |
| 14% | 55% | 29% |

| WOULD YOU BE INTERESTED IN IMPLEMENTING ENERGY EFFICIENCY MEASURES AT YOUR FACILITY | | |
|---|---|---|
| Yes, very interested | Yes, somewhat interested | No |
| 50% | 27% | 9% |

| WOULD YOU MAKE THE EXPENDITURE REQUIRED FOR ENERGY SAVING PROJECTS? | |
|---|---|
| Yes | 49% |
| No, we have no money available | 34% |
| No, we have other priorities for our money | 9% |

| WOULD YOU BORROW MONEY FROM A BANK TO INVEST IN AN ENERGY EFFICIENCY PROJECT? | |
|---|---|
| Yes, we have already done this | 9% |
| Yes, but we need help to arrange credit | 23% |
| Yes, but we don't know of any appropriate investment projects | 20% |
| No, we have other priorities for investment | 40% |

| WOULD YOU BE INTERESTED IN LEARNING MORE ABOUT WAYS TO REDUCE ENERGY COSTS? | | | |
|---|---|---|---|
| Yes, very interested | Yes, somewhat | No, energy is low priority | No, we already know how |
| 57% | 29% | 3% | 6% |

| HAS AN ENERGY AUDIT BEEN CONDUCTED AT YOUR ENTERPRISE? | |
|---|---|
| Yes | No |
| 50% | 46% |

EXHIBIT 2-4
BULGARIA
SURVEY OF LARGEST ELECTRICAL CONSUMERS
DECEMBER 1992 BY ET "DIMITAR BAEV – DBC"

PART 4 – ENERGY CONSERVATION EXPERIENCE, OPPORTUNITIES AND ATTITUDES

| IF YOUR PLANT HAS RECIEVED AN ENERGY AUDIT, HOW SATISFACTORY WERE THE RESULTS? | |
|---|---|
| Yes, we had energy audit and are absolutely satisfied | 3% |
| Yes, we had energy audit and are partially satisfied | 31% |
| Yes, we had energy audits, and it turned out to be useless | 14% |
| No, we have not had an energy audit | 46% |

| WOULD YOU BE INTERESTED AN ENERGY AUDIT PAID FOR BY COE/NEK? | | |
|---|---|---|
| Yes | No | Maybe |
| 70% | 14% | 14% |

| WOULD YOUR FIRM BE WILLING TO PAY FOR ENERGY AUDIT BY BULGARIAN EXPERTS? | |
|---|---|
| Yes, in fact we already hired someone | 11% |
| Yes, we would pay a market price | 31% |
| No, only if we can get it at no cost | 31% |
| No, not interested in an energy audit | 17% |

| ARE YOU AWARE OF ANY ENERGY EFFICIENCY PROGRAMS CARRIED OUT IN BULGARIA BY FOREIGN EXPERTS? | |
|---|---|
| Yes | No |
| 14% | 80% |

| DID YOU HEAR ABOUT THE 1991 INDUSTRIAL ENERGY EFFICIENCY PROGRAM IN BULGARIA SPONSORED BY USAID? | |
|---|---|
| Yes | No |
| 3% | 89% |

# 3. BULGARIA ELECTRICITY DEMAND FORECAST

This Section (1) briefly reviews several of the existing forecasts of electricity use in Bulgaria, (2) explains the scenarios that provide the structure of the demand forecasts, (3) describes the underlying rationale for the electricity forecasts for the several sectors of the Bulgarian economy, and (4) describes the results of the electricity demand forecasts for each scenario.

## 3.1 REVIEW OF PREVIOUS FORECASTS OF ELECTRICITY DEMAND

Several forecasts of electricity demand in Bulgaria have been completed over the past several years. Prior forecasts differ because of differences in scenarios, differences in forecasting techniques, and differences in data. However, the more recent forecasts that build on the data obtained after the initiation of Bulgaria's transition to a market economy will more accurately capture the Bulgarian economy's energy response to this transition and the probable future of electricity demand.

The forecasts are summarized graphically in Exhibit 3-1, and described briefly below.

### 3.1.1 World Bank forecast by Prof. Gordon Hughes in 1991

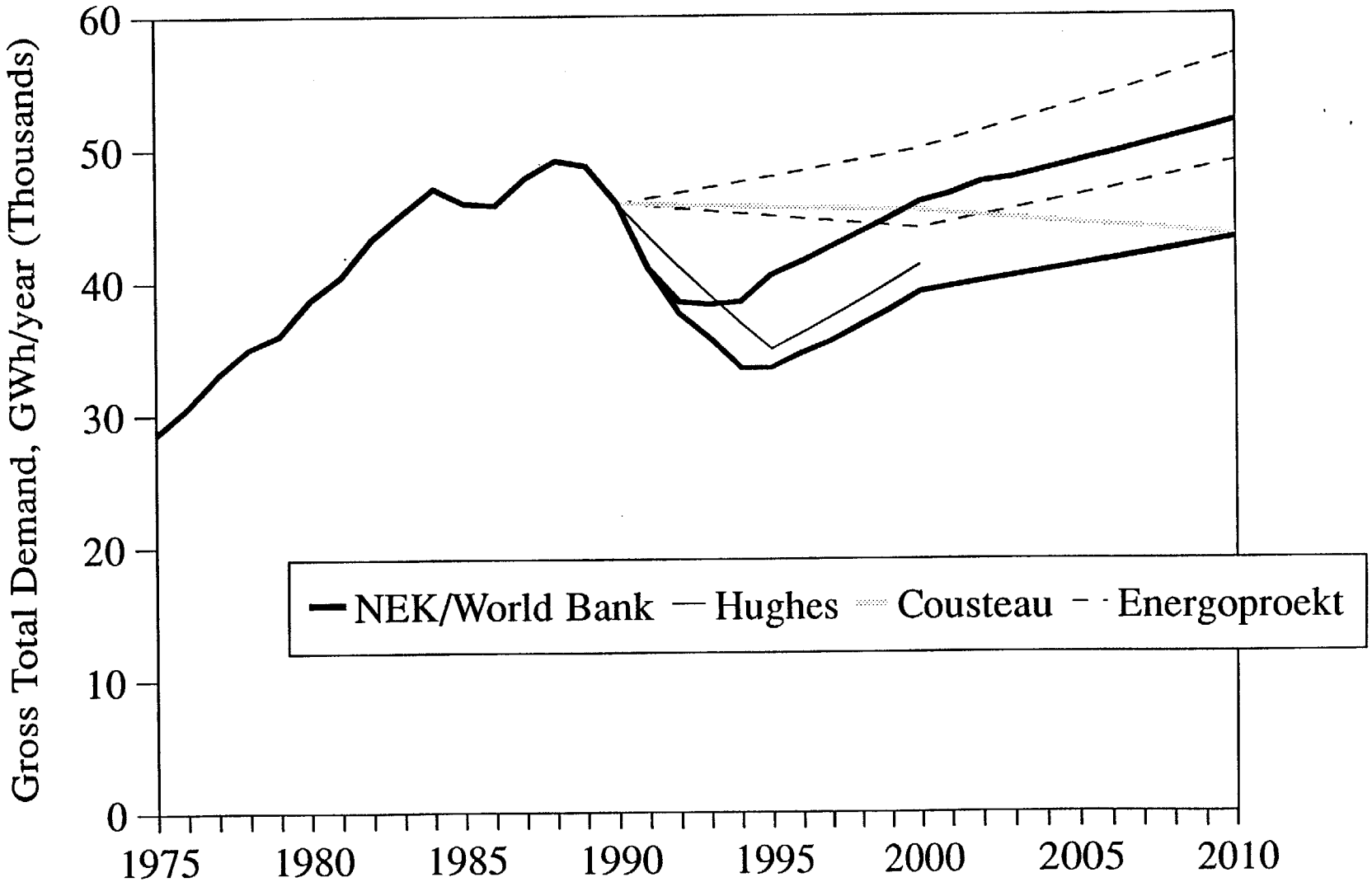
Professor Gordon Hughes performed a forecast in 1991, based on a pooled regression model. He obtained the coefficients for the model from previous analyses of centrally planned economies and analyses of vaguely similar economies in Europe. His forecasts show severe declines in aggregate electricity demand over several time periods as follows:

| | |
|---|---|
| 1989 to 1992 | -29% |
| 1989 to 1995 | -44% |
| 1989 to 2000 | -47% |

Exhibit 3-1

# Bulgaria - Total Electricity Demand

Comparison of Previous Forecasts



Prof. Hughes further uses an energy industry input-output model to look at alternative policy scenarios, where the main policy response is that to electricity price changes. Under this long run interindustry approach, he estimates the following changes to electricity demand:

| | 1989 to 1995 | 1989 to 2000 |
|---|---|---|
| Main Projection | -32% | -15% |
| Low Response | -27% | -16% |
| High Response | -32% | -14% |

The response represents changes in electricity demand due to large changes in the price of electricity, deemed necessary to reach appropriate prices for operating a profitable utility.

### 3.1.2 Forecast by NEK, with guidance from the World Bank, in 1992

For a power system study of the Bulgarian power system at the request of the Group of 7, the World Bank requested a set of demand forecasts from NEK, then worked with NEK in November 1992 to make slight adjustments.

In this forecast, there are three scenarios: maximum, medium, and minimum. The maximum scenarios assumes the most rapid economic growth and the least adjustment by industry to the anticipated higher prices of electricity. The minimum scenario assumes lower economic growth and more adjustment by industry. It also assumes that 450,000 households convert from electricity heating to gas heating after the year 2000. The medium scenario assumes an economic growth between the other two and assumes no major conversions of households to gas heating.

In the medium scenario, electricity demand increases to 52,000 GWh in 2010, and to 56,000 GWh in the maximum scenario. In the minimum scenario, electricity demand increases to 43,200 GWh in 2010. The annual rates of growth in the electricity demand are quite different among these scenarios as can be seen below:

| | **1993 to 2000** | **2000 to 2010** |
|---|---|---|
| Medium | 2.25% | 1.23% |
| Maximum | 3.69% | 1.22% |
| Minimum | 0.60% | 0.98% |

The electricity demand in 2010 for the maximum scenario is approximately 30% larger than that of the minimum scenario.



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### 3.1.3 Energoproekt Forecasts

Energoproekt has furnished several forecasts of electricity demand in the Bulgarian economy. One forecast was done for the United Nations Economic Commission for Europe (ECE) in 1990. This forecast had Bulgarian GDP increasing at about 1.94% per year from 1990 to 2000, with electricity demand increasing from 39,000 GWH to 50,000 GWH, an increase of about 2.5% per year.

In 1991, Energoproekt published a forecast with two scenarios, a high scenario and a low scenario. Both scenarios were based on a GDP growth rate of approximately 2% per year to 2010 (1.94% from 1990 to 2000 and 2.1% from 2000 to 2010). The high forecast shows an increase in electricity demand to 50,000 GWh in 2000 and 57,000 GWh in 2010. This represents an annual rate of increase of 2.5% from 1990 to 2000, and an increase of 1.3% from 2000 to 2010. The low scenario incorporates some energy efficiency into the forecast and forecasts a growth in electricity demand to the year 2000 of 44,000 GWh (an increase of 1.2% per year) and an electricity demand of 49,000 GWh (an increase of 1.1% per year) in the year 2000.

### 3.1.4 Forecast by Equipe Cousteau for the EBRD in 1992

In 1992, Equipe Cousteau prepared a study of the Bulgarian energy future for the European Bank for Reconstruction and Development (EBRD). This study, in collaboration with International Consulting on Energy, was called "Energy in the Danubian Countries, Current Situation, Outlook, and Energy Policy Proposals." The study used the methodology that Energoproekt has used for analyzing the Bulgarian economy, but expanded the methodology to analyze changes in industry structure and improvements in energy efficiency over time. This study assumed that GDP would grow at 2% per year until 2000 and then at 3% per year from 2000 to 2010. Using these assumptions and a decrease in final energy intensity from 0.93 in 1989 to 0.7 in 2000 and 0.5 in 2010, electricity demand decreases from 39,000 GWh in 1989 to 36,500 GWh in 2000 and 35,000 GWh in 2010. This represents a decrease of about 0.67% per year to 2000 and 0.42% per year from 2000 to 2010.

## 3.2 SCENARIOS SELECTED FOR FORECASTING ELECTRICITY DEMAND

For the purposes of this report, three scenarios were developed. The scenario assumptions are summarized briefly in the table below, in terms of the economic growth, electricity efficiency, and other factors important to electricity demand:

**ELECTRICITY DEMAND SCENARIOS**

| Variables | Moderate | Low | High |
|---|---|---|---|
| Economic Growth | low | low | high |
| Inflation | high | high | med |
| Electricity Prices | market | market | market |
| Industry DSM | low | med | high |
| Household DSM | low | med | high |

### 3.2.1 Moderate Scenario: low economic growth - high energy efficiency

This base case scenario reflects a continued difficult economic environment in Bulgaria with low exports, a continued retrenching of industry, high unemployment, high inflation, and high interest rates. Electricity use in industry is low because of successful conservation and increased efficiency programs and because of the reduction in industry output.

Under these assumptions, GDP will decrease by 9% in 1993, 4% in 1994, 1% in 1995 and will level off in 1996. GDP will increase by 1% in 1997 and gradually improve to 3% by the year 2000. Inflation will decrease in 1993 to 50%, to 40% in 1994, and 20% in 1995, with an approximate rate of 10 to 15 percent from 1995 to 2000.

Electricity prices to households are set to market levels by 1996. Government is successful in implementing taxes and incentives for product switching away from products with high energy consumptions. Industries with potential markets and/or a high probability of success will receive the investment necessary for restructuring and installation of technologically advanced and efficient equipment.

### 3.2.2 Low Scenario: low economic growth - moderate energy efficiency

This scenario reflects a continued difficult economic environment in Bulgaria with low exports, a continued retrenching of industry, high unemployment, high inflation, and high interest rates. Electricity use in industry is somewhat higher than Scenario 1 because the conservation and increased efficiency programs are only partially successful, but contrariwise electricity use is down because industry output is reduced in electricity intensive industries.

In this case, GDP will decrease by 9% in 1993, 4% in 1994, 1% in 1995 and will stop decreasing at 0% growth in 1996. GDP will increase by 1% in 1997 and gradually improve to 2.5% by the year 2000. Inflation will decrease in 1993 to 50%, to 40% in 1994, and 20% in 1995, with an approximate rate of 10 to 15 percent from 1995 to 2000.

Electricity prices to households are set to market levels by 1996. Government is moderately successful in implementing taxes and incentives for product switching away from products with high energy consumptions. Industries with potential markets and/or a high probability of success receive additional investment, but restructuring is slow and installation of technologically advanced and efficient equipment does not occur as rapidly as anticipated. Some marginal and energy intensive firms are kept in existence keeping energy use higher than desired.

### 3.2.3 High Scenario: high economic growth - moderately high energy efficiency

This scenario reflects a turnaround in the economic environment in Bulgaria with high economic growth in the latter part of the next decade with an increased level of exports, a successful reallocation of resources to growth industries, a restructuring of industry and a growing private sector reducing unemployment, a continued reduction in the inflation rate, and continued reduction in interest rates. Electricity use in industry is somewhat higher than Scenario 1 because the conservation and increased efficiency programs are only partially successful, but contrariwise electricity use is down because industry output is reduced in electricity intensive industries.

In the high case, GDP will decrease by 2% in 1993, will have 0% growth in 1994, and will increase at 1% in 1995. GDP will increase by 1.5% in 1996 and gradually improve to 4.5% by the year 2000. Inflation will decrease in 1993 to 45%, to 35% in 1994, and 20% in 1995, with an approximate rate of 10 to 15 percent from 1995 to 2000.

Electricity prices to households are set to market levels by 1996. Government is moderately successful in implementing taxes and incentives for product switching away from products with high energy consumptions and is also successful in its DSM programs in the household and buildings sector. Industries with potential markets and/or a high probability of success



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receive additional investment, but restructuring is slow and installation of technologically advanced and efficient equipment does not occur as rapidly as anticipated. Some marginal and energy intensive firms are kept in existence keeping energy use higher than desired.

## 3.3 DEMAND FORECASTING TECHNIQUES

The forecasts were divided into three major parts: household, industry, and the commercial/institutions sectors. The reason for this categorization lies in the way in which the Bulgarian data is collected as well as the nature of the changes that the Bulgarian economy and infrastructure are undergoing.

### 3.3.1 Household Sector

As noted in Chapter 1, household energy consumption is a function of household income, electricity prices, and technical factors. The amount of income that a family has will affect the number of appliances, the size of the structure, and general concerns about electricity use, given the price structure for electricity. The price of electricity will also affect the usage because higher priced electricity, given the proportion of the budget, will reduce the amount of income available for other, perhaps discretionary, items. The number of people and buildings clearly has a direct relationship on the amount of electricity used.

In the household sector, people use electricity as one of the basic necessities of life: for heat, cooking, lighting, etc. The amount of electricity used will depend on the configuration of the heating system, the number of appliances, the age of the appliances, the amount of lighting, and the general patterns of electricity use.

Electricity consumption is first a function of the number and size of households primarily and then a function of real income and the real price of electricity. However, considering that population is stable in Bulgaria, the analysis can be simplified.

We first developed an econometric equation based on income and price elasticities. The estimation used elasticities of income and price that are slightly higher than one would expect for a centralized economy and lower than that of a free market economy. The price elasticity was high, because the real price of electricity in Bulgaria generally declined for the last 12 years, with only variation from the long term trend in 1990 and 1991. The partial elasticities are:

| | |
|---|---|
| Elasticity of real income | 0.603 |
| Elasticity of real electricity price | -0.381 |

However, the analysis revealed that the large price increases expected in the first few years caused the forecast to drop below what we judged to be bare minimum for heating, cooking, and light. Therefore, we adjusted the results to account for these technical factors.

### 3.3.2 Industrial and Other Sectors

As described in Chapter 2, a survey of the largest electricity customers was conducted, and consumption data for large customers and by industrial sector was obtained from NEK. These data served as the basis for a disaggregated approach, developing estimates of prospects for each of the large customers, and for each sector.

We identified the electricity use patterns in the separate industries and developed forecasts of electricity use at this disaggregate industry level. We also identified those industries with more mature domestic markets and international markets that are most likely to succeed. In addition, estimates were made of the likely changes in electricity intensity in each industry in the future, as Bulgaria develops in the direction of the intensities in Western Europe industries. The speed of the changes will depend on the growth of domestic and international markets and the focus of the government programs.

The survey was used, in part, to assess assumptions about the industrial sector for 1992 and 1993. In general, the survey corroborated our assumptions and the trends that had been observed over 1991 and 1992. Every industry except timber and building materials (with no positive indicators) had at least one company that was doing better in 1992 than in 1991, however, the majority of the firms were doing worse. Although the majority of the firms are optimistic about the future (which was to be expected), it appears from the data provided by the companies that only the engineering industry and the textile industry expect to have firms that will do substantially better during 1993. Capacity utilization dropped in 1992 and appears to be dropping further, although not as drastically, in 1993.

We used the survey results to forecast demand on an individual basis for 1993 and beyond. In addition, the survey shed light on the speed of privatization and general restructuring of industry. The privatization process is perceived to be very slow and the investment that accompanies this privatization and the refurbishment of the capital stock will take longer than anticipated. As a result, the industrial outlook is much more pessimistic than that of the Bulgarian policy makers and other analyses. The firms in some industries expect that the next year will be relatively tough for most firms in those industries. These include iron and steel, non-ferrous metals, chemicals, engineering, glass, and electrical equipment. On the other hand, the engineering industry has firms that expect to do very well as well as those firms that expect to retrench considerably.

The following industries were forecast as higher than average growth sectors:

- electrical equipment and electronics
- glass and ceramics
- agriculture
- transportation and communication

The following industries were forecast as relatively average growth sectors:

- non-ferrous metals
- engineered metal products
- textiles
- food and beverage
- construction
- public sector buildings

The following industries were forecast as lower than average growth sectors:

- iron & steel (ferrous metals)
- chemicals
- building materials
- timber
- pulp & paper

### 3.3.3 Peak Power Demand

The peak demand (maximum annual recorded level for one hour during the year) is a function of installed equipment, the operation of that equipment, and weather conditions.



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Over the past few years, peak demand has declined less than energy consumption. This "decoupling" is expected to continue.

Because of the strong influence of weather conditions, peak demand in the household sector is not expected to reduce much unless electric heating is replaced. In the industrial and other sectors, peak demand can only be reduced by further factory shutdowns, which the survey does not seem to support.

Future changes in peak demand will depend mainly on the possible recovery of equipment which has been shut down, or installation of new electrical equipment over time. Secondary effects will result from the future development of prices during peak periods, and the possible installation of demand control equipment. For the purposes of this analysis, these effects have been simulated by tracking the rate of change of GDP.

### 3.3.4 Forecasting losses and generation requirements

The demand forecasts are forecasts first of energy sales. The sales forecasts were then increased (to achieve "total demand") by adding estimated losses and station use of electricity. Station use was held constant at 11.1% of gross generation. Losses were brought back to a historical normal level of 11.5% (of energy for distribution) over a five year period. Exports and imports were ignored, and power purchases were held constant.

## 3.4 DEMAND FORECAST RESULTS

The results and detailed assumptions on a year-to-year basis are shown in a series of exhibits.

### 3.4.1 Expected Case - Moderate Scenario

The expected case is shown in Exhibit 3-2. The first page is a summary, and the subsequent three pages show the build-up of industrial and other sales.

- demand for electricity in the household sector continues to decline, reaching a minimum of 8,400 GWh in 1995, then climbs, reaching 11,000 GWh in 2010.
- in the industrial sector, demand drops slightly, with a minimum of 13,300 GWh in 1994-96, and then begins a gradual climb to 17,000 GWh in 2010.
- total electricity sales reach a minimum of 28,000 GWh in 1994-96 and then rise gradually to its 1988 level of 35,600 GWh around year 2008.



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- peak demand reaches a minimum of 6,500 MW in 1994-95, then increases to 9,600 MW by 2010. The 1989 peak of 8,332 MW is reached again in year 2005.

### 3.4.2 Low Demand Scenario

The low demand case is shown in Exhibit 3-3. The first page is a summary, and the subsequent three pages show the build-up of industrial and other sales.

- demand for electricity in the household sector continues to decline, reaching a minimum of 8,000 GWh in 1995, then climbs, reaching 10,000 GWh in 2010.

- in the industrial sector, demand continues to drop, with a minimum of 12,500 GWh in 1996-97, and then begins a gradual climb to 15,000 GWh in 2010.

- total electricity sales reach a minimum of 26,600 GWh in 1995-96 and then rise gradually to 32,000 GWh in year 2010, but never reach the 1988 level of 35,600 GWh.

- peak demand reaches a minimum of 6,100 MW in 1994-97, then increases to 8,300 MW by 2010, the same as the historical maximum of 8,332 recorded in 1989.



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**Exhibit 3-2**
**BULGARIA**
**ELECTRICITY DEMAND FORECAST**
**EXPECTED CASE – MODERATE SCENARIO**

| | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **ASSUMPTIONS** | | | | | | | | | | | | | | | | | | |
| GDP Growth | −5.0% | −2.0% | 0.0% | 1.0% | 1.5% | 2.0% | 2.5% | 3.0% | 3.0% | 3.0% | 3.0% | 3.0% | 3.0% | 3.0% | 3.0% | 3.0% | 3.0% | 3.0% |
| Real Electricity Price Changes | | | | | | | | | | | | | | | | | | |
| Households | 75.0% | 50.0% | 25.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| Industry | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| Population Growth | 0.2% | 0.2% | 0.2% | 0.2% | 0.2% | 0.2% | 0.2% | 0.2% | 0.2% | 0.2% | 0.2% | 0.2% | 0.2% | 0.2% | 0.2% | 0.2% | 0.2% | 0.2% |
| **Changes in Industrial Electricity Intensity** | | | | | | | | | | | | | | | | | | |
| Growth Sectors | −4.0% | 0.0% | 5.0% | 8.5% | 11.5% | 17.0% | 22.5% | 18.0% | 18.0% | 13.0% | 13.0% | 13.0% | 10.5% | 10.5% | 10.5% | 10.5% | 8.0% | 8.0% |
| Constant Sectors | −6.0% | −3.0% | 0.0% | 1.0% | 1.5% | 3.0% | 3.5% | 4.0% | 4.0% | 4.0% | 4.0% | 4.0% | 4.0% | 4.0% | 4.0% | 4.0% | 4.0% | 4.0% |
| Declining Sectors | −9.0% | −6.0% | −4.0% | −3.0% | 0.5% | 1.0% | 2.5% | 3.0% | 3.0% | 3.0% | 3.0% | 3.0% | 3.0% | 3.0% | 3.0% | 3.0% | 3.0% | 3.0% |
| **FORECAST OF ELECTRICITY SALES, GWh/year** | | | | | | | | | | | | | | | | | | |
| Household Sector | 8,990 | 8,548 | 8,398 | 8,465 | 8,559 | 8,681 | 8,830 | 9,008 | 9,190 | 9,376 | 9,565 | 9,759 | 9,956 | 10,157 | 10,362 | 10,572 | 10,785 | 11,003 |
| Industry Sector | 13,484 | 13,296 | 13,267 | 13,303 | 13,417 | 13,621 | 13,898 | 14,186 | 14,485 | 14,762 | 15,047 | 15,339 | 15,620 | 15,907 | 16,202 | 16,502 | 16,788 | 17,079 |
| Other Sectors | 6,050 | 6,090 | 6,182 | 6,301 | 6,411 | 6,480 | 6,564 | 6,662 | 6,762 | 6,846 | 6,931 | 7,017 | 7,104 | 7,192 | 7,282 | 7,372 | 7,464 | 7,557 |
| **Total Sales** | **28,525** | **27,934** | **27,847** | **28,070** | **28,387** | **28,782** | **29,291** | **29,856** | **30,437** | **30,984** | **31,543** | **32,114** | **32,680** | **33,257** | **33,846** | **34,447** | **35,037** | **35,639** |
| **FORECAST OF GENERATION REQUIREMENTS, GWh/year** | | | | | | | | | | | | | | | | | | |
| Distribution Losses | 4,119 | 3,887 | 3,725 | 3,603 | 3,489 | 3,534 | 3,592 | 3,656 | 3,721 | 3,782 | 3,844 | 3,908 | 3,970 | 4,034 | 4,099 | 4,165 | 4,230 | 4,295 |
| Losses (pct of for distribution) | 13.5% | 13.0% | 12.5% | 12.0% | 11.5% | 11.5% | 11.5% | 11.5% | 11.5% | 11.5% | 11.5% | 11.5% | 11.5% | 11.5% | 11.5% | 11.5% | 11.5% | 11.5% |
| For Distribution | 30,509 | 29,897 | 29,798 | 30,023 | 30,341 | 30,732 | 31,238 | 31,792 | 32,360 | 32,889 | 33,429 | 33,981 | 34,524 | 35,077 | 35,642 | 36,218 | 36,780 | 37,352 |
| Power Purchases from Factories & Others | 750 | 750 | 750 | 750 | 750 | 750 | 750 | 750 | 750 | 750 | 750 | 750 | 750 | 750 | 750 | 750 | 750 | 750 |
| Imports | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Exports | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Factory Self-Generation | 3,024 | 2,975 | 2,975 | 2,999 | 3,035 | 3,084 | 3,145 | 3,221 | 3,298 | 3,377 | 3,458 | 3,541 | 3,626 | 3,713 | 3,803 | 3,894 | 3,987 | 4,083 |
| Power Plant Auxiliaries | 4,058 | 3,975 | 3,961 | 3,992 | 4,035 | 4,089 | 4,157 | 4,233 | 4,310 | 4,383 | 4,456 | 4,531 | 4,606 | 4,681 | 4,758 | 4,837 | 4,913 | 4,991 |
| Auxiliaries (pct of gross generation) | 11.1% | 11.1% | 11.1% | 11.2% | 11.2% | 11.2% | 11.2% | 11.2% | 11.2% | 11.2% | 11.2% | 11.2% | 11.2% | 11.2% | 11.1% | 11.1% | 11.1% | 11.1% |
| **Gross Total Demand** | **36,701** | **35,795** | **35,533** | **35,664** | **35,912** | **36,405** | **37,041** | **37,745** | **38,469** | **39,149** | **39,843** | **40,554** | **41,256** | **41,972** | **42,703** | **43,448** | **44,180** | **44,926** |
| Peak Demand (MW) | 6,650 | 6,517 | 6,517 | 6,582 | 6,681 | 6,815 | 6,985 | 7,194 | 7,410 | 7,633 | 7,862 | 8,097 | 8,340 | 8,591 | 8,848 | 9,114 | 9,387 | 9,669 |

MOD_SUM.WK1

**Exhibit 3–2 (continued)**
**BULGARIA**
**ELECTRICITY DEMAND FORECAST**
**EXPECTED CASE – MODERATE DEMAND SCENARIO**

| | FORECAST OF INDUSTRIAL SALES, GWh/year | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
| **TOTAL INDUSTRIAL SALES** | **13,484** | **13,296** | **13,267** | **13,303** | **13,417** | **13,621** | **13,898** | **14,186** | **14,485** | **14,762** | **15,047** | **15,339** | **15,620** | **15,907** | **16,202** | **16,502** | **16,788** | **17,079** |
| **Ferrous Metals** | **2,146** | **2,120** | **2,120** | **2,129** | **2,141** | **2,167** | **2,197** | **2,233** | **2,268** | **2,305** | **2,341** | **2,379** | **2,417** | **2,456** | **2,495** | **2,535** | **2,575** | **2,617** |
| Promet (S) | 44 | 44 | 44 | 44 | 44 | 45 | 45 | 46 | 47 | 47 | 48 | 49 | 50 | 50 | 51 | 52 | 53 | 54 |
| Kremikovtsi (S) | 840 | 830 | 830 | 833 | 838 | 848 | 860 | 874 | 888 | 902 | 917 | 931 | 946 | 961 | 977 | 992 | 1,008 | 1,024 |
| Stomana | 475 | 469 | 469 | 471 | 474 | 480 | 486 | 494 | 502 | 510 | 518 | 527 | 535 | 543 | 552 | 561 | 570 | 579 |
| Other | 787 | 777 | 777 | 780 | 785 | 794 | 806 | 818 | 832 | 845 | 858 | 872 | 886 | 900 | 915 | 929 | 944 | 959 |
| **Non–ferrous Metals** | **1,512** | **1,494** | **1,494** | **1,500** | **1,509** | **1,527** | **1,549** | **1,573** | **1,598** | **1,624** | **1,650** | **1,676** | **1,703** | **1,731** | **1,758** | **1,786** | **1,815** | **1,844** |
| Medril Mihi | 53 | 52 | 52 | 53 | 53 | 53 | 54 | 55 | 56 | 57 | 58 | 59 | 60 | 61 | 62 | 63 | 64 | 65 |
| Chiprovech | 21 | 21 | 21 | 21 | 21 | 21 | 22 | 22 | 22 | 23 | 23 | 23 | 24 | 24 | 25 | 25 | 25 | 26 |
| Polimet | 39 | 38 | 38 | 39 | 39 | 39 | 40 | 41 | 41 | 42 | 42 | 43 | 44 | 45 | 45 | 46 | 47 | 47 |
| MDP "Elatsite" | 17 | 17 | 17 | 17 | 17 | 17 | 17 | 17 | 18 | 18 | 18 | 19 | 19 | 19 | 20 | 20 | 20 | 20 |
| GORYBSO–AD IVru | 26 | 26 | 26 | 26 | 26 | 26 | 26 | 27 | 27 | 28 | 28 | 29 | 29 | 30 | 30 | 31 | 31 | 32 |
| OTSK–OOD | 114 | 113 | 113 | 113 | 114 | 115 | 117 | 119 | 121 | 123 | 124 | 126 | 128 | 131 | 133 | 135 | 137 | 139 |
| Olovo i Tsink | 22 | 21 | 21 | 22 | 22 | 22 | 22 | 23 | 23 | 23 | 24 | 24 | 24 | 25 | 25 | 26 | 26 | 27 |
| OP "Elatsite" | 391 | 386 | 386 | 387 | 390 | 394 | 400 | 406 | 413 | 419 | 426 | 433 | 440 | 447 | 454 | 461 | 469 | 476 |
| Redki Metali | 17 | 17 | 17 | 17 | 17 | 17 | 18 | 18 | 18 | 18 | 19 | 19 | 19 | 20 | 20 | 20 | 21 | 21 |
| Medodobiven K. (S) | 260 | 257 | 257 | 258 | 259 | 263 | 266 | 271 | 275 | 279 | 284 | 288 | 293 | 298 | 302 | 307 | 312 | 317 |
| D. Blagoev (S) | 200 | 198 | 198 | 199 | 200 | 202 | 205 | 208 | 212 | 215 | 219 | 222 | 226 | 229 | 233 | 237 | 240 | 244 |
| Alumina | 33 | 33 | 33 | 33 | 33 | 34 | 34 | 35 | 35 | 36 | 37 | 37 | 38 | 38 | 39 | 40 | 40 | 41 |
| OTSM (S) | 40 | 39 | 39 | 39 | 39 | 40 | 41 | 41 | 42 | 43 | 43 | 44 | 45 | 45 | 46 | 47 | 48 | 48 |
| Other | 280 | 276 | 276 | 277 | 279 | 282 | 286 | 291 | 295 | 300 | 305 | 310 | 315 | 320 | 325 | 330 | 336 | 341 |
| **Chemicals** | **2,664** | **2,600** | **2,559** | **2,528** | **2,533** | **2,543** | **2,569** | **2,599** | **2,631** | **2,662** | **2,694** | **2,727** | **2,759** | **2,792** | **2,826** | **2,860** | **2,894** | **2,929** |
| Kaltsit (S) | 55 | 54 | 53 | 52 | 52 | 53 | 53 | 54 | 54 | 55 | 56 | 56 | 57 | 58 | 58 | 59 | 60 | 60 |
| Neftohim (S) | 116 | 113 | 111 | 110 | 110 | 110 | 111 | 113 | 114 | 115 | 117 | 118 | 120 | 121 | 123 | 124 | 126 | 127 |
| Agropolihim | 118 | 116 | 114 | 112 | 113 | 113 | 114 | 116 | 117 | 118 | 120 | 121 | 123 | 124 | 126 | 127 | 129 | 130 |
| Polimeri | 110 | 107 | 105 | 104 | 104 | 105 | 106 | 107 | 108 | 110 | 111 | 112 | 114 | 115 | 116 | 118 | 119 | 121 |
| TK "Sodi"–star | 36 | 35 | 35 | 34 | 35 | 35 | 35 | 35 | 36 | 36 | 37 | 37 | 38 | 38 | 38 | 39 | 39 | 40 |
| F "Neohim" | 169 | 165 | 162 | 160 | 161 | 161 | 163 | 165 | 167 | 169 | 171 | 173 | 175 | 177 | 179 | 182 | 184 | 186 |
| Agrabiohim | 560 | 547 | 538 | 532 | 533 | 535 | 540 | 547 | 553 | 560 | 567 | 573 | 580 | 587 | 594 | 601 | 609 | 616 |
| HIMKO | 438 | 428 | 421 | 416 | 417 | 418 | 422 | 428 | 433 | 438 | 443 | 448 | 454 | 459 | 465 | 470 | 476 | 482 |
| Yambolen | 52 | 51 | 50 | 49 | 49 | 49 | 50 | 51 | 51 | 52 | 52 | 53 | 54 | 54 | 55 | 56 | 56 | 57 |
| Plasthin | 21 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 21 | 21 | 21 | 21 | 22 | 22 | 22 | 22 | 23 |
| Lateks (S) | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 8 | 8 | 8 |
| Geoson | 22 | 21 | 21 | 21 | 21 | 21 | 21 | 21 | 22 | 22 | 22 | 23 | 23 | 23 | 23 | 24 | 24 | 24 |
| Gavril Genov (S) | 14 | 13 | 13 | 13 | 13 | 13 | 13 | 13 | 14 | 14 | 14 | 14 | 14 | 14 | 15 | 15 | 15 | 15 |
| P. Karaminchev | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 13 | 13 | 13 | 13 | 13 | 13 | 14 | 14 |
| Smyadovo–OOD | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 6 | 6 | 6 | 6 | 6 |
| Odesos (S) | 13 | 13 | 13 | 12 | 12 | 13 | 13 | 13 | 13 | 13 | 13 | 13 | 14 | 14 | 14 | 14 | 14 | 14 |
| Antibiotik (S) | 109 | 106 | 105 | 104 | 104 | 104 | 105 | 106 | 108 | 109 | 110 | 112 | 113 | 114 | 116 | 117 | 119 | 120 |
| Other | 807 | 787 | 775 | 765 | 767 | 770 | 778 | 787 | 796 | 806 | 816 | 825 | 835 | 845 | 855 | 866 | 876 | 887 |

**Exhibit 3–2 (continued)**
**BULGARIA**
**ELECTRICITY DEMAND FORECAST**
**EXPECTED CASE – MODERATE DEMAND SCENARIO**

| | FORECAST OF INDUSTRIAL SALES, GWh/year | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
| **Engineering – metallic products** | **1,832** | **1,810** | **1,810** | **1,817** | **1,828** | **1,850** | **1,876** | **1,906** | **1,936** | **1,967** | **1,999** | **2,031** | **2,063** | **2,096** | **2,130** | **2,164** | **2,199** | **2,234** |
| Energorem. 3–D (S) | 17 | 17 | 17 | 17 | 17 | 17 | 17 | 18 | 18 | 18 | 18 | 19 | 19 | 19 | 20 | 20 | 20 | 21 |
| K–t za Traktori | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 13 | 13 | 13 | 13 | 13 | 14 | 14 | 14 | 14 | 15 |
| Osam | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 11 | 11 | 11 | 11 | 11 | 11 | 12 | 12 | 12 | 12 | 12 |
| Akumikar | 17 | 17 | 17 | 17 | 17 | 17 | 17 | 18 | 18 | 18 | 19 | 19 | 19 | 19 | 20 | 20 | 20 | 21 |
| Fitingi | 24 | 23 | 23 | 23 | 24 | 24 | 24 | 25 | 25 | 25 | 26 | 26 | 27 | 27 | 27 | 28 | 28 | 29 |
| LEKO–KO | 33 | 33 | 33 | 33 | 33 | 34 | 34 | 35 | 35 | 36 | 36 | 37 | 38 | 38 | 39 | 39 | 40 | 41 |
| SLZ (S) | 21 | 20 | 20 | 20 | 21 | 21 | 21 | 21 | 22 | 22 | 23 | 23 | 23 | 24 | 24 | 24 | 25 | 25 |
| ZTM–OOD (S) | 24 | 23 | 23 | 23 | 24 | 24 | 24 | 25 | 25 | 25 | 26 | 26 | 27 | 27 | 27 | 28 | 28 | 29 |
| Korabostr. –OOD | 11 | 11 | 11 | 11 | 11 | 11 | 11 | 11 | 12 | 12 | 12 | 12 | 12 | 13 | 13 | 13 | 13 | 13 |
| Madara | 21 | 21 | 21 | 21 | 21 | 21 | 21 | 22 | 22 | 23 | 23 | 23 | 24 | 24 | 24 | 25 | 25 | 26 |
| G. Dimitrov (S) | 14 | 14 | 14 | 14 | 14 | 14 | 14 | 15 | 15 | 15 | 15 | 16 | 16 | 16 | 16 | 17 | 17 | 17 |
| TKEP "6 Sept." (S) | 17 | 17 | 17 | 17 | 17 | 17 | 17 | 18 | 18 | 18 | 18 | 19 | 19 | 19 | 20 | 20 | 20 | 21 |
| ZMM–AD (S) | 17 | 17 | 17 | 17 | 17 | 18 | 18 | 18 | 18 | 19 | 19 | 19 | 20 | 20 | 20 | 21 | 21 | 21 |
| MK "VMZ" | 82 | 81 | 81 | 82 | 82 | 83 | 84 | 86 | 87 | 88 | 90 | 91 | 93 | 94 | 96 | 97 | 99 | 100 |
| Progres | 13 | 13 | 13 | 13 | 13 | 13 | 13 | 13 | 13 | 14 | 14 | 14 | 14 | 15 | 15 | 15 | 15 | 16 |
| Varn. Korabostr. (S) | 42 | 41 | 41 | 41 | 42 | 42 | 43 | 44 | 44 | 45 | 46 | 46 | 47 | 48 | 49 | 49 | 50 | 51 |
| Veslets 91 | 50 | 50 | 50 | 50 | 50 | 51 | 52 | 53 | 53 | 54 | 55 | 56 | 57 | 58 | 59 | 60 | 61 | 62 |
| KAMET (S) | 25 | 25 | 25 | 25 | 25 | 25 | 26 | 26 | 27 | 27 | 27 | 28 | 28 | 29 | 29 | 30 | 30 | 31 |
| Rekora (S) | 16 | 16 | 16 | 16 | 16 | 16 | 16 | 16 | 17 | 17 | 17 | 17 | 18 | 18 | 18 | 19 | 19 | 19 |
| Other | 1,366 | 1,350 | 1,350 | 1,355 | 1,363 | 1,380 | 1,399 | 1,421 | 1,444 | 1,467 | 1,491 | 1,515 | 1,539 | 1,563 | 1,588 | 1,614 | 1,640 | 1,666 |
| **Electrical & Electronics** | **639** | **639** | **652** | **674** | **705** | **753** | **821** | **880** | **944** | **993** | **1,044** | **1,099** | **1,145** | **1,193** | **1,243** | **1,295** | **1,337** | **1,379** |
| B. Kolarov | 25 | 25 | 26 | 27 | 28 | 30 | 32 | 35 | 37 | 39 | 41 | 43 | 45 | 47 | 49 | 51 | 53 | 54 |
| Eltos | 11 | 11 | 11 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 19 | 20 | 21 | 22 | 23 | 23 |
| Feromagniti | 19 | 19 | 20 | 20 | 21 | 23 | 25 | 27 | 28 | 30 | 31 | 33 | 35 | 36 | 37 | 39 | 40 | 42 |
| Svetlkna | 15 | 15 | 15 | 16 | 16 | 18 | 19 | 21 | 22 | 23 | 24 | 26 | 27 | 28 | 29 | 30 | 31 | 32 |
| Elprom–Dinamo | 9 | 9 | 9 | 10 | 10 | 11 | 12 | 13 | 14 | 14 | 15 | 16 | 17 | 17 | 18 | 19 | 19 | 20 |
| Elprom–ZEM–ad (S) | 16 | 16 | 16 | 16 | 17 | 18 | 20 | 21 | 23 | 24 | 25 | 27 | 28 | 29 | 30 | 31 | 32 | 33 |
| D S U | 17 | 17 | 17 | 17 | 18 | 20 | 21 | 23 | 24 | 26 | 27 | 28 | 30 | 31 | 32 | 34 | 35 | 36 |
| Elima | 19 | 19 | 19 | 20 | 21 | 22 | 24 | 26 | 28 | 29 | 31 | 32 | 34 | 35 | 37 | 38 | 39 | 41 |
| Elkom (S) | 12 | 12 | 12 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 21 | 22 | 23 | 24 | 25 |
| Other | 497 | 497 | 507 | 525 | 549 | 586 | 639 | 685 | 734 | 772 | 813 | 855 | 891 | 928 | 967 | 1,008 | 1,040 | 1,073 |
| **Building Materials** | **981** | **969** | **969** | **973** | **979** | **991** | **1,005** | **1,021** | **1,037** | **1,054** | **1,070** | **1,088** | **1,105** | **1,123** | **1,141** | **1,159** | **1,177** | **1,196** |
| Beloiz. Tsiment | 53 | 53 | 53 | 53 | 53 | 54 | 55 | 55 | 56 | 57 | 58 | 59 | 60 | 61 | 62 | 63 | 64 | 65 |
| Devn. Tsiment | 101 | 99 | 99 | 100 | 100 | 102 | 103 | 105 | 106 | 108 | 110 | 112 | 113 | 115 | 117 | 119 | 121 | 123 |
| Bulkan | 36 | 35 | 35 | 36 | 36 | 36 | 37 | 37 | 38 | 39 | 39 | 40 | 40 | 41 | 42 | 42 | 43 | 44 |
| Izida | 16 | 16 | 16 | 16 | 16 | 16 | 16 | 17 | 17 | 17 | 17 | 18 | 18 | 18 | 19 | 19 | 19 | 20 |
| Pl. Tsiment | 59 | 58 | 58 | 58 | 59 | 59 | 60 | 61 | 62 | 63 | 64 | 65 | 66 | 67 | 68 | 70 | 71 | 72 |
| Zl. Panega | 87 | 86 | 86 | 86 | 87 | 88 | 89 | 90 | 92 | 93 | 95 | 96 | 98 | 99 | 101 | 102 | 104 | 106 |
| Han Asparuh (S) | 16 | 16 | 16 | 16 | 16 | 16 | 17 | 17 | 17 | 18 | 18 | 18 | 18 | 19 | 19 | 19 | 20 | 20 |
| Kaolin (S) | 18 | 18 | 18 | 18 | 18 | 18 | 18 | 19 | 19 | 19 | 20 | 20 | 20 | 21 | 21 | 21 | 22 | 22 |
| Other | 595 | 588 | 588 | 591 | 594 | 601 | 610 | 619 | 629 | 639 | 650 | 660 | 671 | 681 | 692 | 703 | 715 | 726 |
| Timber | 267 | 261 | 257 | 254 | 254 | 255 | 258 | 261 | 264 | 267 | 270 | 274 | 277 | 280 | 283 | 287 | 290 | 294 |

**Exhibit 3–2 (continued)**
**BULGARIA**
**ELECTRICITY DEMAND FORECAST**
**EXPECTED CASE – MODERATE DEMAND SCENARIO**

| | FORECAST OF INDUSTRIAL SALES, GWh/year | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
| **Pulp & paper, wood products** | **347** | **338** | **333** | **329** | **330** | **331** | **334** | **338** | **342** | **346** | **350** | **355** | **359** | **363** | **368** | **372** | **376** | **381** |
| Rulon–Iskar (S) | 27 | 26 | 26 | 26 | 26 | 26 | 26 | 26 | 27 | 27 | 27 | 28 | 28 | 28 | 29 | 29 | 29 | 30 |
| PHHI | 23 | 23 | 23 | 22 | 22 | 22 | 23 | 23 | 23 | 23 | 24 | 24 | 24 | 25 | 25 | 25 | 25 | 26 |
| TKTSH | 55 | 53 | 52 | 52 | 52 | 52 | 53 | 53 | 54 | 54 | 55 | 56 | 56 | 57 | 58 | 59 | 59 | 60 |
| ZMK (S) | 38 | 37 | 36 | 36 | 36 | 36 | 37 | 37 | 37 | 38 | 38 | 39 | 39 | 40 | 40 | 41 | 41 | 42 |
| Lesil | 16 | 16 | 16 | 16 | 16 | 16 | 16 | 16 | 16 | 16 | 17 | 17 | 17 | 17 | 17 | 18 | 18 | 18 |
| St. Kirajiev (S) | 55 | 54 | 53 | 52 | 53 | 53 | 53 | 54 | 55 | 55 | 56 | 57 | 57 | 58 | 59 | 59 | 60 | 61 |
| TKHTS (S) | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 11 | 11 | 11 | 11 | 11 | 11 | 11 | 11 |
| Other | 122 | 119 | 117 | 115 | 116 | 116 | 117 | 119 | 120 | 122 | 123 | 125 | 126 | 128 | 129 | 131 | 132 | 134 |
| **Glass** | **459** | **459** | **468** | **484** | **507** | **541** | **590** | **632** | **678** | **713** | **750** | **789** | **822** | **857** | **893** | **930** | **960** | **991** |
| Belopal | 37 | 37 | 38 | 39 | 41 | 44 | 48 | 51 | 55 | 58 | 61 | 64 | 67 | 69 | 72 | 75 | 78 | 80 |
| Kitka | 25 | 25 | 25 | 26 | 27 | 29 | 32 | 34 | 37 | 38 | 40 | 43 | 44 | 46 | 48 | 50 | 52 | 53 |
| Fayans | 26 | 26 | 26 | 27 | 29 | 31 | 33 | 36 | 38 | 40 | 42 | 44 | 46 | 48 | 50 | 52 | 54 | 56 |
| Rubin | 25 | 25 | 25 | 26 | 27 | 29 | 32 | 34 | 36 | 38 | 40 | 42 | 44 | 46 | 48 | 50 | 51 | 53 |
| Drushba | 43 | 43 | 44 | 45 | 47 | 51 | 55 | 59 | 63 | 67 | 70 | 74 | 77 | 80 | 84 | 87 | 90 | 93 |
| Kvarts | 18 | 18 | 18 | 19 | 20 | 21 | 23 | 25 | 26 | 28 | 29 | 31 | 32 | 33 | 35 | 36 | 37 | 39 |
| Diamant (S) | 21 | 21 | 21 | 22 | 23 | 25 | 27 | 29 | 31 | 33 | 34 | 36 | 38 | 39 | 41 | 43 | 44 | 45 |
| Other | 265 | 265 | 270 | 279 | 292 | 312 | 340 | 365 | 391 | 411 | 432 | 455 | 474 | 494 | 515 | 536 | 554 | 571 |
| **Textiles** | **559** | **552** | **552** | **554** | **558** | **564** | **572** | **581** | **591** | **600** | **610** | **619** | **629** | **639** | **650** | **660** | **671** | **681** |
| Manuela | 23 | 22 | 22 | 23 | 23 | 23 | 23 | 24 | 24 | 24 | 25 | 25 | 26 | 26 | 26 | 27 | 27 | 28 |
| Dobruja | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 10 | 10 | 10 | 10 | 10 | 10 | 11 | 11 |
| Sliteks | 20 | 20 | 20 | 20 | 20 | 21 | 21 | 21 | 22 | 22 | 22 | 23 | 23 | 23 | 24 | 24 | 24 | 25 |
| Vratitsa | 14 | 14 | 14 | 14 | 14 | 14 | 14 | 14 | 15 | 15 | 15 | 15 | 16 | 16 | 16 | 16 | 17 | 17 |
| Other | 493 | 487 | 487 | 489 | 492 | 498 | 505 | 513 | 521 | 530 | 538 | 547 | 555 | 564 | 573 | 582 | 592 | 601 |
| **Food & Beverage** | **1,178** | **1,164** | **1,164** | **1,169** | **1,176** | **1,190** | **1,206** | **1,226** | **1,245** | **1,265** | **1,285** | **1,306** | **1,327** | **1,348** | **1,370** | **1,392** | **1,414** | **1,437** |
| N. Vaptsarov | 32 | 32 | 32 | 32 | 32 | 32 | 33 | 33 | 34 | 34 | 35 | 36 | 36 | 37 | 37 | 38 | 38 | 39 |
| Tyot. Kombinat (S) | 11 | 11 | 11 | 11 | 11 | 11 | 11 | 11 | 12 | 12 | 12 | 12 | 12 | 13 | 13 | 13 | 13 | 13 |
| MEZ "Kambana" (S) | 76 | 75 | 75 | 75 | 76 | 77 | 78 | 79 | 80 | 82 | 83 | 84 | 86 | 87 | 88 | 90 | 91 | 93 |
| SKPPPMYA (S) | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 11 | 11 | 11 | 11 | 11 | 11 | 12 | 12 | 12 |
| Other | 1,049 | 1,037 | 1,037 | 1,041 | 1,047 | 1,060 | 1,074 | 1,092 | 1,109 | 1,127 | 1,145 | 1,163 | 1,182 | 1,201 | 1,220 | 1,239 | 1,259 | 1,279 |
| **Other Industries** | **900** | **889** | **889** | **893** | **898** | **909** | **921** | **936** | **951** | **966** | **982** | **997** | **1,013** | **1,030** | **1,046** | **1,063** | **1,080** | **1,097** |
| Bules (S) | 14 | 13 | 13 | 14 | 14 | 14 | 14 | 14 | 14 | 15 | 15 | 15 | 15 | 16 | 16 | 16 | 16 | 17 |
| Cherno More (S) | 9 | 9 | 9 | 9 | 9 | 9 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 11 | 11 | 11 | 11 | 11 |
| **Construction** | **679** | **671** | **671** | **673** | **677** | **686** | **695** | **706** | **718** | **729** | **741** | **753** | **765** | **777** | **789** | **802** | **815** | **828** |
| **Agriculture** | **891** | **902** | **920** | **942** | **957** | **964** | **974** | **986** | **998** | **1,010** | **1,022** | **1,034** | **1,046** | **1,059** | **1,072** | **1,085** | **1,098** | **1,111** |
| **Transport & Communications** | **1,419** | **1,451** | **1,494** | **1,545** | **1,585** | **1,614** | **1,646** | **1,682** | **1,719** | **1,740** | **1,761** | **1,782** | **1,803** | **1,825** | **1,847** | **1,869** | **1,891** | **1,914** |
| **Public Sector** | **3,061** | **3,067** | **3,097** | **3,141** | **3,191** | **3,217** | **3,249** | **3,288** | **3,327** | **3,367** | **3,408** | **3,448** | **3,490** | **3,532** | **3,574** | **3,617** | **3,660** | **3,704** |

MOD_IND.WK1

**Exhibit 3–3**
**BULGARIA**
**ELECTRICITY DEMAND FORECAST**
**LOW DEMAND SCENARIO**

| | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **ASSUMPTIONS** | | | | | | | | | | | | | | | | | | |
| GDP Growth | −9.0% | −4.0% | −1.0% | 0.0% | 1.0% | 1.5% | 2.0% | 2.5% | 2.5% | 2.5% | 2.5% | 2.5% | 2.5% | 2.5% | 2.5% | 2.5% | 2.5% | 2.5% |
| Real Electricity Price Changes | | | | | | | | | | | | | | | | | | |
| Households | 75.0% | 50.0% | 25.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| Industry | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| Population Growth | 0.2% | 0.2% | 0.2% | 0.2% | 0.2% | 0.2% | 0.2% | 0.2% | 0.2% | 0.2% | 0.2% | 0.2% | 0.2% | 0.2% | 0.2% | 0.2% | 0.2% | 0.2% |
| **Changes in Industrial Electricity Intensity** | | | | | | | | | | | | | | | | | | |
| Growth Sectors | −9.0% | −3.0% | 1.5% | 5.0% | 8.5% | 11.5% | 12.0% | 12.5% | 12.5% | 12.5% | 12.5% | 12.5% | 10.0% | 10.0% | 10.0% | 10.0% | 7.5% | 7.5% |
| Constant Sectors | −12.0% | −7.0% | −3.0% | −1.0% | 1.0% | 2.5% | 3.0% | 3.5% | 3.5% | 3.5% | 3.5% | 3.5% | 3.5% | 3.5% | 3.5% | 3.5% | 3.5% | 3.5% |
| Declining Sectors | −17.0% | −11.5% | −8.0% | −5.0% | −4.0% | −3.5% | −0.5% | 1.5% | 2.5% | 2.5% | 2.5% | 2.5% | 2.5% | 2.5% | 2.5% | 2.5% | 2.5% | 2.5% |
| **FORECAST OF ELECTRICITY SALES, GWh/year** | | | | | | | | | | | | | | | | | | |
| Household Sector | 8,759 | 8,221 | 8,027 | 8,043 | 8,108 | 8,198 | 8,314 | 8,457 | 8,602 | 8,750 | 8,900 | 9,053 | 9,208 | 9,366 | 9,527 | 9,691 | 9,857 | 10,027 |
| Industry Sector | 13,186 | 12,777 | 12,582 | 12,510 | 12,536 | 12,634 | 12,789 | 12,990 | 13,207 | 13,430 | 13,658 | 13,892 | 14,116 | 14,344 | 14,578 | 14,816 | 15,041 | 15,269 |
| Other Sectors | 5,948 | 5,935 | 5,996 | 6,085 | 6,179 | 6,234 | 6,302 | 6,383 | 6,466 | 6,533 | 6,601 | 6,670 | 6,739 | 6,809 | 6,880 | 6,952 | 7,025 | 7,098 |
| **Total Sales** | **27,893** | **26,933** | **26,605** | **26,638** | **26,822** | **27,065** | **27,404** | **27,830** | **28,275** | **28,713** | **29,159** | **29,614** | **30,063** | **30,520** | **30,985** | **31,459** | **31,923** | **32,394** |
| **FORECAST OF GENERATION REQUIREMENTS, GWh/year** | | | | | | | | | | | | | | | | | | |
| Distribution Losses | 4,038 | 3,761 | 3,573 | 3,435 | 3,313 | 3,340 | 3,378 | 3,426 | 3,476 | 3,525 | 3,575 | 3,626 | 3,676 | 3,727 | 3,778 | 3,831 | 3,882 | 3,934 |
| Losses (pct of for distribution) | 13.5% | 13.0% | 12.5% | 12.0% | 11.5% | 11.5% | 11.5% | 11.5% | 11.5% | 11.5% | 11.5% | 11.5% | 11.5% | 11.5% | 11.5% | 11.5% | 11.5% | 11.5% |
| For Distribution | 29,910 | 28,930 | 28,585 | 28,623 | 28,805 | 29,042 | 29,373 | 29,788 | 30,224 | 30,650 | 31,085 | 31,528 | 31,963 | 32,405 | 32,855 | 33,313 | 33,759 | 34,211 |
| **Power Purchases from Factories & Others** | 750 | 750 | 750 | 750 | 750 | 750 | 750 | 750 | 750 | 750 | 750 | 750 | 750 | 750 | 750 | 750 | 750 | 750 |
| Imports | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Exports | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Factory Self–Generation | 2,923 | 2,829 | 2,807 | 2,807 | 2,829 | 2,863 | 2,909 | 2,967 | 3,027 | 3,087 | 3,149 | 3,212 | 3,276 | 3,342 | 3,408 | 3,477 | 3,546 | 3,617 |
| Power Plant Auxiliaries | 3,976 | 3,843 | 3,796 | 3,801 | 3,826 | 3,858 | 3,903 | 3,960 | 4,019 | 4,077 | 4,137 | 4,197 | 4,256 | 4,317 | 4,378 | 4,440 | 4,501 | 4,563 |
| Auxiliaries (pct of gross generation) | 11.1% | 11.1% | 11.2% | 11.2% | 11.3% | 11.3% | 11.3% | 11.2% | 11.2% | 11.2% | 11.2% | 11.2% | 11.2% | 11.2% | 11.2% | 11.2% | 11.2% | 11.2% |
| **Gross Total Demand** | **35,907** | **34,536** | **33,974** | **33,874** | **33,960** | **34,263** | **34,685** | **35,215** | **35,770** | **36,315** | **36,870** | **37,437** | **37,995** | **38,563** | **39,142** | **39,730** | **40,306** | **40,891** |
| **Peak Demand (MW)** | **6,370** | **6,115** | **6,054** | **6,054** | **6,115** | **6,206** | **6,330** | **6,489** | **6,651** | **6,817** | **6,988** | **7,162** | **7,341** | **7,525** | **7,713** | **7,906** | **8,103** | **8,306** |

LOW_SUMM

22

**Exhibit 3–3 (continued)**
**BULGARIA**
**ELECTRICITY DEMAND FORECAST**
**LOW DEMAND SCENARIO**

| | FORECAST OF INDUSTRIAL SALES, GWh/year | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
| **TOTAL INDUSTRIAL SALES** | 13,186 | 12,777 | 12,582 | 12,510 | 12,536 | 12,634 | 12,789 | 12,990 | 13,207 | 13,430 | 13,658 | 13,892 | 14,116 | 14,344 | 14,578 | 14,816 | 15,041 | 15,269 |
| **Ferrous Metals** | 2,115 | 2,056 | 2,031 | 2,023 | 2,031 | 2,051 | 2,076 | 2,105 | 2,134 | 2,164 | 2,195 | 2,225 | 2,256 | 2,288 | 2,320 | 2,353 | 2,385 | 2,419 |
| Promet (S) | 44 | 43 | 42 | 42 | 42 | 43 | 43 | 44 | 45 | 45 | 46 | 46 | 47 | 48 | 48 | 49 | 50 | 50 |
| Kremikovtsi (S) | 840 | 817 | 807 | 804 | 807 | 815 | 825 | 836 | 848 | 860 | 872 | 884 | 896 | 909 | 922 | 935 | 948 | 961 |
| Stomana | 463 | 450 | 445 | 443 | 445 | 449 | 455 | 461 | 468 | 474 | 481 | 487 | 494 | 501 | 508 | 515 | 523 | 530 |
| Other | 767 | 746 | 737 | 734 | 737 | 744 | 753 | 764 | 774 | 785 | 796 | 807 | 819 | 830 | 842 | 854 | 866 | 878 |
| **Non–ferrous Metals** | 1,487 | 1,446 | 1,428 | 1,423 | 1,428 | 1,443 | 1,460 | 1,480 | 1,501 | 1,522 | 1,543 | 1,565 | 1,587 | 1,609 | 1,632 | 1,654 | 1,678 | 1,701 |
| Medril Mihi | 52 | 50 | 50 | 49 | 50 | 50 | 51 | 51 | 52 | 53 | 54 | 54 | 55 | 56 | 57 | 57 | 58 | 59 |
| Chiprovech | 21 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 21 | 21 | 21 | 22 | 22 | 22 | 23 | 23 | 23 | 24 |
| Polimet | 38 | 37 | 36 | 36 | 36 | 37 | 37 | 38 | 38 | 39 | 39 | 40 | 41 | 41 | 42 | 42 | 43 | 43 |
| MDP "Elatsite" | 16 | 16 | 16 | 16 | 16 | 16 | 16 | 16 | 17 | 17 | 17 | 17 | 17 | 18 | 18 | 18 | 18 | 19 |
| GORYBSO–AD IVru | 25 | 24 | 24 | 24 | 24 | 24 | 25 | 25 | 25 | 26 | 26 | 27 | 27 | 27 | 28 | 28 | 28 | 29 |
| OTSK–OOD | 111 | 108 | 107 | 106 | 107 | 108 | 109 | 111 | 112 | 114 | 115 | 117 | 119 | 120 | 122 | 124 | 126 | 127 |
| Olovo i Tsink | 21 | 21 | 20 | 20 | 20 | 21 | 21 | 21 | 21 | 22 | 22 | 22 | 23 | 23 | 23 | 24 | 24 | 24 |
| OP "Elatsite" | 381 | 370 | 366 | 364 | 366 | 370 | 374 | 379 | 385 | 390 | 395 | 401 | 407 | 412 | 418 | 424 | 430 | 436 |
| Redki Metali | 17 | 16 | 16 | 16 | 16 | 16 | 16 | 17 | 17 | 17 | 17 | 18 | 18 | 18 | 18 | 19 | 19 | 19 |
| Medodobiven K. (S) | 260 | 253 | 250 | 249 | 250 | 252 | 255 | 259 | 262 | 266 | 270 | 274 | 277 | 281 | 285 | 289 | 293 | 297 |
| D. Blagoev (S) | 200 | 195 | 192 | 192 | 192 | 194 | 197 | 199 | 202 | 205 | 208 | 211 | 214 | 217 | 220 | 223 | 226 | 229 |
| Alumina | 33 | 32 | 31 | 31 | 31 | 32 | 32 | 32 | 33 | 33 | 34 | 34 | 35 | 35 | 36 | 36 | 37 | 37 |
| OTSM (S) | 40 | 38 | 38 | 38 | 38 | 38 | 39 | 39 | 40 | 41 | 41 | 42 | 42 | 43 | 43 | 44 | 45 | 45 |
| Other | 273 | 265 | 262 | 261 | 262 | 264 | 268 | 271 | 275 | 279 | 283 | 287 | 291 | 295 | 299 | 303 | 308 | 312 |
| **Chemicals** | 2,586 | 2,467 | 2,388 | 2,341 | 2,303 | 2,271 | 2,266 | 2,280 | 2,303 | 2,326 | 2,349 | 2,373 | 2,396 | 2,420 | 2,444 | 2,469 | 2,494 | 2,518 |
| Kaltsit (S) | 55 | 52 | 51 | 50 | 49 | 48 | 48 | 48 | 49 | 49 | 50 | 50 | 51 | 51 | 52 | 53 | 53 | 54 |
| Neftohim (S) | 116 | 110 | 107 | 105 | 103 | 101 | 101 | 102 | 103 | 104 | 105 | 106 | 107 | 108 | 109 | 110 | 111 | 113 |
| Agropolihim | 114 | 109 | 106 | 104 | 102 | 101 | 100 | 101 | 102 | 103 | 104 | 105 | 106 | 107 | 108 | 109 | 110 | 111 |
| Polimeri | 106 | 101 | 98 | 96 | 94 | 93 | 93 | 93 | 94 | 95 | 96 | 97 | 98 | 99 | 100 | 101 | 102 | 103 |
| TK "Sodi"–star | 35 | 33 | 32 | 32 | 31 | 31 | 31 | 31 | 31 | 32 | 32 | 32 | 33 | 33 | 33 | 33 | 34 | 34 |
| F "Neohim" | 164 | 156 | 151 | 148 | 146 | 144 | 143 | 144 | 146 | 147 | 149 | 150 | 152 | 153 | 155 | 156 | 158 | 159 |
| Agrabiohim | 542 | 517 | 500 | 490 | 482 | 476 | 475 | 478 | 482 | 487 | 492 | 497 | 502 | 507 | 512 | 517 | 522 | 527 |
| HIMKO | 424 | 404 | 391 | 383 | 377 | 372 | 371 | 373 | 377 | 381 | 385 | 389 | 393 | 396 | 400 | 404 | 408 | 413 |
| Yambolen | 50 | 48 | 46 | 45 | 45 | 44 | 44 | 44 | 45 | 45 | 45 | 46 | 46 | 47 | 47 | 48 | 48 | 49 |
| Plasthin | 20 | 19 | 18 | 18 | 18 | 18 | 17 | 18 | 18 | 18 | 18 | 18 | 18 | 19 | 19 | 19 | 19 | 19 |
| Lateks (S) | 7 | 7 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 7 | 7 | 7 | 7 | 7 |
| Geoson | 21 | 20 | 20 | 19 | 19 | 19 | 19 | 19 | 19 | 19 | 19 | 20 | 20 | 20 | 20 | 20 | 21 | 21 |
| Gavril Genov (S) | 14 | 13 | 13 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 13 | 13 | 13 | 13 | 13 | 13 | 13 | 13 |
| P. Karaminchev | 12 | 12 | 11 | 11 | 11 | 11 | 11 | 11 | 11 | 11 | 11 | 11 | 11 | 11 | 11 | 12 | 12 | 12 |
| Smyadovo–OOD | 5 | 5 | 5 | 5 | 5 | 4 | 4 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 |
| Odesos (S) | 13 | 13 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 13 | 13 | 13 |
| Antibiotik (S) | 109 | 104 | 101 | 99 | 97 | 96 | 96 | 96 | 97 | 98 | 99 | 100 | 101 | 102 | 103 | 104 | 105 | 106 |
| Other | 780 | 744 | 720 | 706 | 694 | 685 | 683 | 687 | 694 | 701 | 708 | 715 | 722 | 730 | 737 | 744 | 752 | 759 |

**Exhibit 3–3 (continued)**
**BULGARIA**
**ELECTRICITY DEMAND FORECAST**
**LOW DEMAND SCENARIO**

| | FORECAST OF INDUSTRIAL SALES, GWh/year | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
| **Engineering – metallic products** | **1,791** | **1,741** | **1,720** | **1,713** | **1,720** | **1,737** | **1,758** | **1,783** | **1,808** | **1,833** | **1,859** | **1,885** | **1,911** | **1,938** | **1,965** | **1,992** | **2,020** | **2,048** |
| Energorem. 3–D (S) | 17 | 16 | 16 | 16 | 16 | 16 | 17 | 17 | 17 | 17 | 17 | 18 | 18 | 18 | 18 | 19 | 19 | 19 |
| K–t za Traktori | 12 | 11 | 11 | 11 | 11 | 11 | 11 | 12 | 12 | 12 | 12 | 12 | 12 | 13 | 13 | 13 | 13 | 13 |
| Osam | 10 | 10 | 9 | 9 | 9 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 11 | 11 | 11 | 11 | 11 | 11 |
| Akumikar | 17 | 16 | 16 | 16 | 16 | 16 | 16 | 17 | 17 | 17 | 17 | 17 | 18 | 18 | 18 | 18 | 19 | 19 |
| Fitingi | 23 | 22 | 22 | 22 | 22 | 22 | 23 | 23 | 23 | 24 | 24 | 24 | 25 | 25 | 25 | 26 | 26 | 26 |
| LEKO–KO | 33 | 32 | 31 | 31 | 31 | 32 | 32 | 32 | 33 | 33 | 34 | 34 | 35 | 35 | 36 | 36 | 37 | 37 |
| SLZ (S) | 20 | 20 | 19 | 19 | 19 | 20 | 20 | 20 | 20 | 21 | 21 | 21 | 21 | 22 | 22 | 22 | 23 | 23 |
| ZTM–OOD (S) | 24 | 23 | 23 | 23 | 23 | 23 | 23 | 23 | 24 | 24 | 24 | 25 | 25 | 25 | 26 | 26 | 27 | 27 |
| Korabostr. –OOD | 11 | 10 | 10 | 10 | 10 | 10 | 10 | 11 | 11 | 11 | 11 | 11 | 11 | 12 | 12 | 12 | 12 | 12 |
| Madara | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 21 | 21 | 21 | 22 | 22 | 22 | 22 | 23 | 23 | 23 |
| G. Dimitrov (S) | 14 | 14 | 13 | 13 | 13 | 14 | 14 | 14 | 14 | 14 | 15 | 15 | 15 | 15 | 15 | 16 | 16 | 16 |
| TKEP "6 Sept." (S) | 17 | 16 | 16 | 16 | 16 | 16 | 17 | 17 | 17 | 17 | 18 | 18 | 18 | 18 | 19 | 19 | 19 | 19 |
| ZMM–AD (S) | 17 | 17 | 17 | 17 | 17 | 17 | 17 | 17 | 18 | 18 | 18 | 18 | 19 | 19 | 19 | 19 | 20 | 20 |
| MK "VMZ" | 80 | 78 | 77 | 77 | 77 | 78 | 79 | 80 | 81 | 82 | 83 | 85 | 86 | 87 | 88 | 89 | 91 | 92 |
| Progres | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 13 | 13 | 13 | 13 | 13 | 13 | 14 | 14 | 14 | 14 |
| Varn. Korabostr. (S) | 42 | 41 | 40 | 40 | 40 | 41 | 41 | 42 | 42 | 43 | 43 | 44 | 45 | 45 | 46 | 47 | 47 | 48 |
| Veslets 91 | 49 | 48 | 47 | 47 | 47 | 48 | 48 | 49 | 50 | 50 | 51 | 52 | 53 | 53 | 54 | 55 | 56 | 56 |
| KAMET (S) | 25 | 24 | 24 | 24 | 24 | 24 | 25 | 25 | 25 | 26 | 26 | 27 | 27 | 27 | 28 | 28 | 28 | 29 |
| Rekora (S) | 16 | 15 | 15 | 15 | 15 | 15 | 15 | 16 | 16 | 16 | 16 | 17 | 17 | 17 | 17 | 18 | 18 | 18 |
| Other | 1,333 | 1,295 | 1,280 | 1,275 | 1,280 | 1,293 | 1,308 | 1,326 | 1,345 | 1,364 | 1,383 | 1,402 | 1,422 | 1,442 | 1,462 | 1,482 | 1,503 | 1,524 |
| **Electrical & Electronics** | **627** | **619** | **623** | **636** | **657** | **687** | **720** | **756** | **794** | **834** | **876** | **920** | **956** | **995** | **1,034** | **1,076** | **1,108** | **1,141** |
| B. Kolarov | 25 | 24 | 25 | 25 | 26 | 27 | 28 | 30 | 31 | 33 | 34 | 36 | 38 | 39 | 41 | 42 | 44 | 45 |
| Eltos | 11 | 11 | 11 | 11 | 11 | 12 | 12 | 13 | 13 | 14 | 15 | 16 | 16 | 17 | 18 | 18 | 19 | 19 |
| Feromagniti | 19 | 19 | 19 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 28 | 29 | 30 | 31 | 32 | 33 | 34 |
| Svetlkna | 15 | 14 | 15 | 15 | 15 | 16 | 17 | 18 | 19 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 |
| Elprom–Dinamo | 9 | 9 | 9 | 9 | 10 | 10 | 10 | 11 | 12 | 12 | 13 | 13 | 14 | 14 | 15 | 16 | 16 | 17 |
| Elprom–ZEM–ad (S) | 16 | 15 | 15 | 16 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 27 | 28 |
| D S U | 16 | 16 | 16 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 |
| Elima | 18 | 18 | 18 | 19 | 19 | 20 | 21 | 22 | 23 | 24 | 26 | 27 | 28 | 29 | 30 | 32 | 33 | 33 |
| Elkom (S) | 12 | 11 | 11 | 12 | 12 | 13 | 13 | 14 | 15 | 15 | 16 | 17 | 18 | 18 | 19 | 20 | 20 | 21 |
| Other | 487 | 482 | 484 | 494 | 511 | 534 | 560 | 588 | 617 | 648 | 681 | 715 | 743 | 773 | 804 | 836 | 861 | 887 |
| **Building Materials** | **958** | **931** | **920** | **916** | **920** | **929** | **940** | **953** | **967** | **980** | **994** | **1,008** | **1,022** | **1,036** | **1,051** | **1,065** | **1,080** | **1,095** |
| Beloiz. Tsiment | 52 | 50 | 50 | 50 | 50 | 50 | 51 | 52 | 52 | 53 | 54 | 55 | 55 | 56 | 57 | 58 | 59 | 59 |
| Devn. Tsiment | 98 | 95 | 94 | 94 | 94 | 95 | 96 | 98 | 99 | 100 | 102 | 103 | 105 | 106 | 108 | 109 | 111 | 112 |
| Bulkan | 35 | 34 | 34 | 34 | 34 | 34 | 34 | 35 | 35 | 36 | 36 | 37 | 37 | 38 | 38 | 39 | 40 | 40 |
| Izida | 16 | 15 | 15 | 15 | 15 | 15 | 15 | 16 | 16 | 16 | 16 | 16 | 17 | 17 | 17 | 17 | 18 | 18 |
| Pl. Tsiment | 57 | 56 | 55 | 55 | 55 | 56 | 56 | 57 | 58 | 59 | 60 | 60 | 61 | 62 | 63 | 64 | 65 | 66 |
| Zl. Panega | 85 | 82 | 81 | 81 | 81 | 82 | 83 | 84 | 85 | 87 | 88 | 89 | 90 | 92 | 93 | 94 | 95 | 97 |
| Han Asparuh (S) | 16 | 16 | 16 | 16 | 16 | 16 | 16 | 16 | 16 | 17 | 17 | 17 | 17 | 18 | 18 | 18 | 18 | 19 |
| Kaolin (S) | 18 | 17 | 17 | 17 | 17 | 17 | 18 | 18 | 18 | 18 | 19 | 19 | 19 | 19 | 20 | 20 | 20 | 21 |
| Other | 581 | 564 | 558 | 555 | 558 | 563 | 570 | 578 | 586 | 594 | 603 | 611 | 620 | 628 | 637 | 646 | 655 | 664 |
| Timber | 258 | 247 | 239 | 234 | 230 | 227 | 226 | 228 | 230 | 232 | 235 | 237 | 239 | 242 | 244 | 247 | 249 | 252 |

**Exhibit 3–3 (continued)**
**BULGARIA**
**ELECTRICITY DEMAND FORECAST**
**LOW DEMAND SCENARIO**

| | FORECAST OF INDUSTRIAL SALES, GWh/year | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
| **Pulp & paper, wood products** | **339** | **324** | **313** | **307** | **302** | **298** | **297** | **299** | **302** | **305** | **308** | **311** | **314** | **318** | **321** | **324** | **327** | **331** |
| Rulon–Iskar (S) | 27 | 26 | 25 | 24 | 24 | 24 | 24 | 24 | 24 | 24 | 25 | 25 | 25 | 25 | 26 | 26 | 26 | 26 |
| PHHI | 23 | 22 | 21 | 21 | 20 | 20 | 20 | 20 | 20 | 20 | 21 | 21 | 21 | 21 | 21 | 22 | 22 | 22 |
| TKTSH | 53 | 50 | 49 | 48 | 47 | 46 | 46 | 46 | 47 | 47 | 48 | 48 | 49 | 49 | 50 | 50 | 51 | 51 |
| ZMK (S) | 38 | 36 | 35 | 34 | 34 | 33 | 33 | 33 | 34 | 34 | 34 | 35 | 35 | 35 | 36 | 36 | 37 | 37 |
| Lesil | 16 | 15 | 15 | 14 | 14 | 14 | 14 | 14 | 14 | 14 | 14 | 15 | 15 | 15 | 15 | 15 | 15 | 15 |
| St. Kirajiev (S) | 55 | 53 | 51 | 50 | 49 | 48 | 48 | 49 | 49 | 50 | 50 | 51 | 51 | 52 | 52 | 53 | 53 | 54 |
| TKHTS (S) | 10 | 10 | 10 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 10 | 10 | 10 | 10 | 10 | 10 | 10 |
| Other | 118 | 112 | 109 | 106 | 105 | 103 | 103 | 104 | 105 | 106 | 107 | 108 | 109 | 110 | 111 | 112 | 113 | 115 |
| **Glass** | **450** | **445** | **447** | **456** | **472** | **494** | **517** | **543** | **570** | **599** | **629** | **660** | **687** | **714** | **743** | **772** | **796** | **820** |
| Belopal | 36 | 36 | 36 | 37 | 38 | 40 | 42 | 44 | 46 | 49 | 51 | 54 | 56 | 58 | 60 | 63 | 64 | 66 |
| Kitka | 24 | 24 | 24 | 25 | 25 | 27 | 28 | 29 | 31 | 32 | 34 | 36 | 37 | 38 | 40 | 42 | 43 | 44 |
| Fayans | 25 | 25 | 25 | 26 | 27 | 28 | 29 | 31 | 32 | 34 | 35 | 37 | 39 | 40 | 42 | 44 | 45 | 46 |
| Rubin | 24 | 24 | 24 | 24 | 25 | 26 | 28 | 29 | 30 | 32 | 34 | 35 | 37 | 38 | 40 | 41 | 43 | 44 |
| Drushba | 42 | 42 | 42 | 43 | 44 | 46 | 48 | 51 | 53 | 56 | 59 | 62 | 64 | 67 | 69 | 72 | 74 | 77 |
| Kvarts | 18 | 17 | 17 | 18 | 18 | 19 | 20 | 21 | 22 | 23 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 |
| Diamant (S) | 21 | 21 | 21 | 21 | 22 | 23 | 24 | 25 | 27 | 28 | 29 | 31 | 32 | 33 | 35 | 36 | 37 | 38 |
| Other | 259 | 256 | 258 | 263 | 272 | 284 | 298 | 313 | 329 | 345 | 362 | 380 | 396 | 411 | 428 | 445 | 458 | 472 |
| **Textiles** | **545** | **530** | **523** | **521** | **523** | **529** | **535** | **542** | **550** | **558** | **566** | **573** | **582** | **590** | **598** | **606** | **615** | **623** |
| Manuela | 22 | 22 | 21 | 21 | 21 | 21 | 22 | 22 | 22 | 23 | 23 | 23 | 24 | 24 | 24 | 25 | 25 | 25 |
| Dobruja | 9 | 8 | 8 | 8 | 8 | 8 | 8 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 10 | 10 | 10 |
| Sliteks | 20 | 19 | 19 | 19 | 19 | 19 | 19 | 20 | 20 | 20 | 21 | 21 | 21 | 21 | 22 | 22 | 22 | 23 |
| Vratitsa | 13 | 13 | 13 | 13 | 13 | 13 | 13 | 13 | 14 | 14 | 14 | 14 | 14 | 15 | 15 | 15 | 15 | 15 |
| Other | 481 | 468 | 462 | 460 | 462 | 467 | 472 | 479 | 485 | 492 | 499 | 506 | 513 | 520 | 528 | 535 | 543 | 550 |
| **Food & Beverage** | **1,151** | **1,119** | **1,106** | **1,101** | **1,106** | **1,117** | **1,130** | **1,146** | **1,162** | **1,178** | **1,195** | **1,212** | **1,229** | **1,246** | **1,263** | **1,281** | **1,299** | **1,317** |
| N. Vaptsarov | 31 | 30 | 30 | 30 | 30 | 30 | 31 | 31 | 32 | 32 | 32 | 33 | 33 | 34 | 34 | 35 | 35 | 36 |
| Tyot. Kombinat (S) | 11 | 11 | 11 | 11 | 11 | 11 | 11 | 11 | 11 | 11 | 11 | 12 | 12 | 12 | 12 | 12 | 12 | 13 |
| MEZ "Kambana" (S) | 76 | 74 | 73 | 73 | 73 | 74 | 75 | 76 | 77 | 78 | 79 | 80 | 81 | 82 | 83 | 85 | 86 | 87 |
| SKPPPMYA (S) | 10 | 10 | 9 | 9 | 9 | 9 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 11 | 11 | 11 | 11 | 11 |
| Other | 1,023 | 995 | 983 | 979 | 983 | 993 | 1,005 | 1,019 | 1,033 | 1,047 | 1,062 | 1,077 | 1,092 | 1,107 | 1,123 | 1,138 | 1,154 | 1,171 |
| **Other Industries** | **878** | **853** | **843** | **839** | **843** | **851** | **861** | **874** | **886** | **898** | **911** | **923** | **936** | **949** | **963** | **976** | **990** | **1,004** |
| Bules (S) | 14 | 13 | 13 | 13 | 13 | 13 | 13 | 14 | 14 | 14 | 14 | 14 | 15 | 15 | 15 | 15 | 15 | 16 |
| Cherno More (S) | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 11 | 11 |
| **Construction** | **662** | **644** | **636** | **633** | **636** | **642** | **650** | **659** | **668** | **678** | **687** | **697** | **707** | **716** | **726** | **737** | **747** | **757** |
| **Agriculture** | **877** | **880** | **895** | **912** | **925** | **931** | **938** | **948** | **957** | **967** | **976** | **986** | **996** | **1,006** | **1,016** | **1,026** | **1,036** | **1,047** |
| **Transport & Communications** | **1,397** | **1,417** | **1,454** | **1,497** | **1,533** | **1,558** | **1,586** | **1,617** | **1,650** | **1,666** | **1,683** | **1,700** | **1,717** | **1,734** | **1,751** | **1,769** | **1,786** | **1,804** |
| **Public Sector** | **3,012** | **2,994** | **3,012** | **3,042** | **3,084** | **3,103** | **3,128** | **3,159** | **3,191** | **3,222** | **3,255** | **3,287** | **3,320** | **3,353** | **3,387** | **3,421** | **3,455** | **3,489** |

LOW_IND.WK1

### 3.4.3 High Demand Scenario

The high demand case is shown in Exhibit 3-4. Again, the first page is a summary, and the subsequent three pages show the build-up of industrial and other sales.

- demand for electricity in the household sector declines slightly, reaching a minimum of 8,700 GWh in 1995, then climbs, reaching 12,800 GWh in 2010.
- in the industrial sector, demand holds firm at 13,600 GWh until 1996, and then begins a gradual climb to 19,500 GWh in 2010.
- total electricity sales reach a minimum of 28,700 GWh in 1994 and then rise gradually to 41,000 GWh in year 2010, but never reach the 1988 level of 35,600 GWh.
- peak demand holds at 6,900 MW until 1996, then increases to 12,300 MW by 2010, passing the historical maximum of 8,332 in year 2002.

**Exhibit 3–4**
**BULGARIA**
***ELBCTRICITY DEMAND FORECAST***
**HIGH DEMAND SCENARIO**

| | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **ASSUMPTIONS** | | | | | | | | | | | | | | | | | | |
| GDP Growth | −2.0% | 0.0% | 1.0% | 1.5% | 2.0% | 2.8% | 3.3% | 4.5% | 4.5% | 4.5% | 4.5% | 4.5% | 4.5% | 4.5% | 4.5% | 4.5% | 4.5% | 4.5% |
| Real Electricity Price Changes | | | | | | | | | | | | | | | | | | |
| Households | 75.0% | 50.0% | 25.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| Industry | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| Population Growth | 0.2% | 0.2% | 0.2% | 0.2% | 0.2% | 0.2% | 0.2% | 0.2% | 0.2% | 0.2% | 0.2% | 0.2% | 0.2% | 0.2% | 0.2% | 0.2% | 0.2% | 0.2% |
| **Changes in Industrial Electricity Intensity** | | | | | | | | | | | | | | | | | | |
| Growth Sectors | 0.0% | 2.0% | 4.0% | 6.5% | 9.5% | 12.8% | 18.3% | 24.5% | 19.5% | 14.5% | 14.5% | 14.5% | 12.0% | 12.0% | 12.0% | 12.0% | 9.5% | 9.5% |
| Constant Sectors | −3.0% | 0.0% | 1.0% | 1.5% | 3.0% | 4.8% | 6.3% | 9.5% | 8.5% | 7.5% | 6.5% | 5.5% | 5.5% | 5.5% | 5.5% | 5.5% | 5.5% | 5.5% |
| Declining Sectors | −7.0% | −4.0% | −2.0% | −0.5% | 1.0% | 1.8% | 2.8% | 4.5% | 4.5% | 4.5% | 4.5% | 4.5% | 4.5% | 4.5% | 4.5% | 4.5% | 4.5% | 4.5% |
| **FORECAST OF ELECTRICITY SALES, GWh/year** | | | | | | | | | | | | | | | | | | |
| Household Sector | 9,164 | 8,824 | 8,723 | 8,820 | 8,944 | 9,112 | 9,310 | 9,583 | 9,863 | 10,153 | 10,450 | 10,757 | 11,072 | 11,396 | 11,731 | 12,074 | 12,428 | 12,793 |
| Industry Sector | 13,616 | 13,572 | 13,601 | 13,680 | 13,849 | 14,112 | 14,480 | 15,047 | 15,572 | 16,043 | 16,488 | 16,902 | 17,309 | 17,728 | 18,158 | 18,600 | 19,031 | 19,472 |
| Other Sectors | 6,145 | 6,325 | 6,537 | 6,729 | 6,918 | 7,075 | 7,224 | 7,388 | 7,553 | 7,698 | 7,843 | 7,987 | 8,135 | 8,285 | 8,437 | 8,593 | 8,751 | 8,912 |
| **Total Sales** | **28,925** | **28,721** | **28,861** | **29,229** | **29,711** | **30,299** | **31,014** | **32,018** | **32,988** | **33,894** | **34,781** | **35,646** | **36,516** | **37,409** | **38,326** | **39,267** | **40,210** | **41,177** |
| **FORECAST OF GENERATION REQUIREMENTS, GWh/year** | | | | | | | | | | | | | | | | | | |
| Distribution Losses | 4,168 | 3,984 | 3,847 | 3,738 | 3,638 | 3,705 | 3,787 | 3,902 | 4,012 | 4,113 | 4,210 | 4,305 | 4,399 | 4,495 | 4,594 | 4,696 | 4,797 | 4,900 |
| Losses (pct of for distribution) | 13.5% | 13.0% | 12.5% | 12.0% | 11.5% | 11.5% | 11.5% | 11.5% | 11.5% | 11.5% | 11.5% | 11.5% | 11.5% | 11.5% | 11.5% | 11.5% | 11.5% | 11.5% |
| For Distribution | 30,877 | 30,646 | 30,776 | 31,149 | 31,637 | 32,221 | 32,933 | 33,930 | 34,884 | 35,761 | 36,611 | 37,431 | 38,250 | 39,090 | 39,950 | 40,832 | 41,709 | 42,607 |
| **Power Purchases from Factories & Others** | 750 | 750 | 750 | 750 | 750 | 750 | 750 | 750 | 750 | 750 | 750 | 750 | 750 | 750 | 750 | 750 | 750 | 750 |
| Imports | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Exports | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Factory Self–Generation | 3,099 | 3,099 | 3,124 | 3,162 | 3,212 | 3,283 | 3,368 | 3,489 | 3,615 | 3,745 | 3,880 | 4,020 | 4,164 | 4,314 | 4,470 | 4,631 | 4,797 | 4,970 |
| Power Plant Auxiliaries | 4,108 | 4,077 | 4,094 | 4,145 | 4,212 | 4,292 | 4,389 | 4,525 | 4,655 | 4,774 | 4,890 | 5,002 | 5,114 | 5,228 | 5,345 | 5,466 | 5,585 | 5,708 |
| Auxiliaries (pct of gross generation) | 11.0% | 11.1% | 11.1% | 11.2% | 11.2% | 11.2% | 11.2% | 11.2% | 11.2% | 11.2% | 11.1% | 11.1% | 11.1% | 11.1% | 11.1% | 11.1% | 11.0% | 11.0% |
| **Gross Total Demand** | **37,202** | **36,782** | **36,803** | **37,112** | **37,561** | **38,296** | **39,190** | **40,444** | **41,654** | **42,781** | **43,881** | **44,952** | **46,028** | **47,132** | **48,265** | **49,428** | **50,592** | **51,785** |
| **Peak Demand (MW)** | **6,860** | **6,860** | **6,929** | **7,033** | **7,173** | **7,370** | **7,610** | **7,952** | **8,310** | **8,684** | **9,075** | **9,483** | **9,910** | **10,356** | **10,822** | **11,309** | **11,818** | **12,350** |

HIGH_SUM.WKI

**Exhibit 3–4 (continued)**
**BULGARIA**
***ELECTRICITY DEMAND FORECAST***
**HIGH DEMAND SCENARIO**

| FORECAST OF INDUSTRIAL SALES, GWh/year | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **TOTAL INDUSTRIAL SALES** | **13,616** | **13,572** | **13,601** | **13,680** | **13,849** | **14,112** | **14,480** | **15,047** | **15,572** | **16,043** | **16,488** | **16,902** | **17,309** | **17,728** | **18,158** | **18,600** | **19,031** | **19,472** |
| **Ferrous Metals** | **2,161** | **2,161** | **2,170** | **2,183** | **2,209** | **2,251** | **2,307** | **2,395** | **2,477** | **2,551** | **2,617** | **2,675** | **2,734** | **2,794** | **2,855** | **2,918** | **2,982** | **3,048** |
| Promet (S) | 44 | 44 | 44 | 45 | 45 | 46 | 47 | 49 | 51 | 52 | 53 | 55 | 56 | 57 | 58 | 60 | 61 | 62 |
| Kremikovtsi (S) | 840 | 840 | 844 | 849 | 859 | 875 | 897 | 931 | 963 | 992 | 1,017 | 1,040 | 1,063 | 1,086 | 1,110 | 1,134 | 1,159 | 1,185 |
| Stomana | 481 | 481 | 483 | 486 | 491 | 501 | 513 | 533 | 551 | 567 | 582 | 595 | 608 | 621 | 635 | 649 | 663 | 678 |
| Other | 796 | 796 | 800 | 804 | 814 | 829 | 850 | 882 | 912 | 940 | 964 | 985 | 1,007 | 1,029 | 1,052 | 1,075 | 1,099 | 1,123 |
| **Non–ferrous Metals** | **1,525** | **1,525** | **1,531** | **1,540** | **1,558** | **1,588** | **1,628** | **1,690** | **1,747** | **1,799** | **1,846** | **1,887** | **1,928** | **1,971** | **2,014** | **2,058** | **2,104** | **2,150** |
| Medril Mihi | 54 | 54 | 54 | 54 | 55 | 56 | 57 | 59 | 61 | 63 | 65 | 66 | 68 | 69 | 71 | 72 | 74 | 76 |
| Chiprovech | 21 | 21 | 21 | 22 | 22 | 22 | 23 | 24 | 24 | 25 | 26 | 26 | 27 | 28 | 28 | 29 | 29 | 30 |
| Polimet | 39 | 39 | 40 | 40 | 40 | 41 | 42 | 44 | 45 | 47 | 48 | 49 | 50 | 51 | 52 | 53 | 54 | 56 |
| MDP "Elatsite" | 17 | 17 | 17 | 17 | 17 | 18 | 18 | 19 | 19 | 20 | 21 | 21 | 22 | 22 | 22 | 23 | 23 | 24 |
| GORYBSO–AD IVru | 26 | 26 | 26 | 26 | 27 | 27 | 28 | 29 | 30 | 31 | 32 | 32 | 33 | 34 | 35 | 35 | 36 | 37 |
| OTSK–OOD | 115 | 115 | 116 | 117 | 118 | 120 | 123 | 128 | 132 | 136 | 140 | 143 | 146 | 149 | 153 | 156 | 159 | 163 |
| Olovo i Tsink | 22 | 22 | 22 | 22 | 22 | 23 | 23 | 24 | 25 | 26 | 27 | 27 | 28 | 28 | 29 | 30 | 30 | 31 |
| OP "Elatsite" | 395 | 395 | 397 | 399 | 404 | 412 | 422 | 438 | 453 | 467 | 479 | 489 | 500 | 511 | 522 | 534 | 546 | 558 |
| Redki Metali | 17 | 17 | 18 | 18 | 18 | 18 | 19 | 19 | 20 | 21 | 21 | 22 | 22 | 23 | 23 | 24 | 24 | 25 |
| Medodobiven K. (S) | 260 | 260 | 261 | 263 | 266 | 271 | 278 | 288 | 298 | 307 | 315 | 322 | 329 | 336 | 343 | 351 | 359 | 367 |
| D. Blagoev (S) | 200 | 200 | 201 | 202 | 205 | 209 | 214 | 222 | 230 | 236 | 243 | 248 | 253 | 259 | 265 | 270 | 276 | 282 |
| Alumina | 34 | 34 | 34 | 34 | 35 | 35 | 36 | 38 | 39 | 40 | 41 | 42 | 43 | 44 | 45 | 46 | 47 | 48 |
| OTSM (S) | 40 | 40 | 40 | 40 | 40 | 41 | 42 | 44 | 45 | 47 | 48 | 49 | 50 | 51 | 52 | 53 | 55 | 56 |
| Other | 283 | 283 | 284 | 286 | 289 | 295 | 302 | 314 | 324 | 334 | 343 | 350 | 358 | 366 | 374 | 382 | 390 | 399 |
| **Chemicals** | **2,684** | **2,641** | **2,620** | **2,614** | **2,625** | **2,643** | **2,672** | **2,721** | **2,769** | **2,819** | **2,870** | **2,922** | **2,974** | **3,028** | **3,082** | **3,138** | **3,194** | **3,252** |
| Kaltsit (S) | 55 | 54 | 54 | 54 | 54 | 54 | 55 | 56 | 57 | 58 | 59 | 60 | 61 | 62 | 63 | 64 | 65 | 67 |
| Neftohim (S) | 116 | 114 | 113 | 113 | 113 | 114 | 115 | 117 | 119 | 121 | 124 | 126 | 128 | 130 | 133 | 135 | 138 | 140 |
| Agropolihim | 119 | 117 | 117 | 116 | 117 | 118 | 119 | 121 | 123 | 125 | 128 | 130 | 132 | 135 | 137 | 140 | 142 | 145 |
| Polimeri | 111 | 109 | 108 | 108 | 108 | 109 | 110 | 112 | 114 | 116 | 118 | 120 | 123 | 125 | 127 | 129 | 132 | 134 |
| TK "Sodi"–star | 37 | 36 | 36 | 36 | 36 | 36 | 36 | 37 | 38 | 38 | 39 | 40 | 41 | 41 | 42 | 43 | 44 | 44 |
| F "Neohim" | 171 | 168 | 166 | 166 | 167 | 168 | 170 | 173 | 176 | 179 | 182 | 186 | 189 | 192 | 196 | 199 | 203 | 207 |
| Agrabiohim | 565 | 556 | 551 | 550 | 553 | 556 | 563 | 573 | 583 | 593 | 604 | 615 | 626 | 637 | 649 | 660 | 672 | 684 |
| HIMKO | 442 | 435 | 431 | 430 | 432 | 435 | 440 | 448 | 456 | 464 | 473 | 481 | 490 | 499 | 507 | 517 | 526 | 535 |
| Yambolen | 52 | 51 | 51 | 51 | 51 | 51 | 52 | 53 | 54 | 55 | 56 | 57 | 58 | 59 | 60 | 61 | 62 | 63 |
| Plasthin | 21 | 20 | 20 | 20 | 20 | 20 | 21 | 21 | 21 | 22 | 22 | 23 | 23 | 23 | 24 | 24 | 25 | 25 |
| Lateks (S) | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 8 | 8 | 8 | 8 | 8 | 8 | 8 |
| Geoson | 22 | 22 | 22 | 22 | 22 | 22 | 22 | 22 | 23 | 23 | 24 | 24 | 25 | 25 | 25 | 26 | 26 | 27 |
| Gavril Genov (S) | 14 | 14 | 13 | 13 | 14 | 14 | 14 | 14 | 14 | 15 | 15 | 15 | 15 | 16 | 16 | 16 | 16 | 17 |
| P. Karaminchev | 13 | 12 | 12 | 12 | 12 | 12 | 13 | 13 | 13 | 13 | 13 | 14 | 14 | 14 | 14 | 15 | 15 | 15 |
| Smyadovo–OOD | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 |
| Odesos (S) | 13 | 13 | 13 | 13 | 13 | 13 | 13 | 13 | 14 | 14 | 14 | 14 | 15 | 15 | 15 | 15 | 16 | 16 |
| Antibiotik (S) | 109 | 107 | 106 | 106 | 107 | 107 | 109 | 111 | 113 | 115 | 117 | 119 | 121 | 123 | 125 | 128 | 130 | 132 |
| Other | 813 | 800 | 794 | 792 | 795 | 801 | 810 | 824 | 839 | 854 | 870 | 885 | 901 | 917 | 934 | 951 | 968 | 985 |

**Exhibit 3–4 (continued)**
**BULGARIA**
**ELECTRICITY DEMAND FORECAST**
**HIGH DEMAND SCENARIO**

**FORECAST OF INDUSTRIAL SALES, GWh/year**

| | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Engineering – metallic products** | **1,852** | **1,852** | **1,860** | **1,871** | **1,893** | **1,929** | **1,977** | **2,053** | **2,122** | **2,186** | **2,243** | **2,292** | **2,343** | **2,394** | **2,447** | **2,501** | **2,556** | **2,612** |
| Energorem. 3–D (S) | 17 | 17 | 17 | 17 | 17 | 18 | 18 | 19 | 19 | 20 | 20 | 21 | 21 | 22 | 22 | 23 | 23 | 24 |
| K–t za Traktori | 12 | 12 | 12 | 12 | 12 | 13 | 13 | 13 | 14 | 14 | 15 | 15 | 15 | 16 | 16 | 16 | 17 | 17 |
| Osam | 10 | 10 | 10 | 10 | 10 | 11 | 11 | 11 | 12 | 12 | 12 | 13 | 13 | 13 | 14 | 14 | 14 | 14 |
| Akumikar | 17 | 17 | 17 | 17 | 18 | 18 | 18 | 19 | 20 | 20 | 21 | 21 | 22 | 22 | 23 | 23 | 24 | 24 |
| Fitingi | 24 | 24 | 24 | 24 | 24 | 25 | 25 | 26 | 27 | 28 | 29 | 30 | 30 | 31 | 31 | 32 | 33 | 34 |
| LEKO–KO | 34 | 34 | 34 | 34 | 35 | 35 | 36 | 37 | 39 | 40 | 41 | 42 | 43 | 44 | 45 | 46 | 47 | 48 |
| SLZ (S) | 21 | 21 | 21 | 21 | 21 | 22 | 22 | 23 | 24 | 25 | 25 | 26 | 26 | 27 | 28 | 28 | 29 | 29 |
| ZTM–OOD (S) | 24 | 24 | 24 | 24 | 24 | 25 | 25 | 26 | 27 | 28 | 29 | 29 | 30 | 30 | 31 | 32 | 32 | 33 |
| Korabostr. –OOD | 11 | 11 | 11 | 11 | 11 | 12 | 12 | 12 | 13 | 13 | 13 | 14 | 14 | 14 | 15 | 15 | 15 | 16 |
| Madara | 21 | 21 | 21 | 21 | 22 | 22 | 23 | 24 | 24 | 25 | 26 | 26 | 27 | 27 | 28 | 29 | 29 | 30 |
| G. Dimitrov (S) | 14 | 14 | 14 | 14 | 14 | 15 | 15 | 16 | 16 | 17 | 17 | 17 | 18 | 18 | 18 | 19 | 19 | 20 |
| TKEP "6 Sept." (S) | 17 | 17 | 17 | 17 | 17 | 18 | 18 | 19 | 19 | 20 | 21 | 21 | 21 | 22 | 22 | 23 | 23 | 24 |
| ZMM–AD (S) | 17 | 17 | 17 | 18 | 18 | 18 | 19 | 19 | 20 | 21 | 21 | 22 | 22 | 22 | 23 | 23 | 24 | 25 |
| MK "VMZ" | 83 | 83 | 84 | 84 | 85 | 87 | 89 | 92 | 96 | 98 | 101 | 103 | 105 | 108 | 110 | 113 | 115 | 118 |
| Progres | 13 | 13 | 13 | 13 | 13 | 13 | 14 | 14 | 15 | 15 | 16 | 16 | 16 | 17 | 17 | 17 | 18 | 18 |
| Varn. Korabostr. (S) | 42 | 42 | 42 | 42 | 43 | 44 | 45 | 46 | 48 | 49 | 51 | 52 | 53 | 54 | 55 | 56 | 58 | 59 |
| Veslets 91 | 51 | 51 | 51 | 52 | 52 | 53 | 55 | 57 | 59 | 60 | 62 | 63 | 65 | 66 | 68 | 69 | 71 | 72 |
| KAMET (S) | 25 | 25 | 25 | 25 | 26 | 26 | 27 | 28 | 29 | 30 | 31 | 31 | 32 | 33 | 33 | 34 | 35 | 36 |
| Rekora (S) | 16 | 16 | 16 | 16 | 16 | 16 | 17 | 17 | 18 | 19 | 19 | 19 | 20 | 20 | 21 | 21 | 22 | 22 |
| Other | 1,383 | 1,383 | 1,389 | 1,397 | 1,414 | 1,441 | 1,477 | 1,533 | 1,585 | 1,632 | 1,675 | 1,712 | 1,749 | 1,788 | 1,827 | 1,867 | 1,908 | 1,950 |
| **Electrical & Electronics** | **649** | **655** | **665** | **682** | **708** | **744** | **799** | **877** | **945** | **1,000** | **1,058** | **1,120** | **1,173** | **1,230** | **1,289** | **1,351** | **1,402** | **1,455** |
| B. Kolarov | 26 | 26 | 26 | 27 | 28 | 29 | 31 | 35 | 37 | 39 | 42 | 44 | 46 | 48 | 51 | 53 | 55 | 57 |
| Eltos | 11 | 11 | 11 | 12 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 |
| Feromagniti | 20 | 20 | 20 | 21 | 21 | 22 | 24 | 26 | 29 | 30 | 32 | 34 | 35 | 37 | 39 | 41 | 42 | 44 |
| Svetlkna | 15 | 15 | 16 | 16 | 17 | 17 | 19 | 20 | 22 | 23 | 25 | 26 | 27 | 29 | 30 | 32 | 33 | 34 |
| Elprom–Dinamo | 9 | 10 | 10 | 10 | 10 | 11 | 12 | 13 | 14 | 15 | 15 | 16 | 17 | 18 | 19 | 20 | 20 | 21 |
| Elprom–ZEM–ad (S) | 16 | 16 | 16 | 16 | 17 | 18 | 19 | 21 | 23 | 24 | 25 | 27 | 28 | 29 | 31 | 32 | 33 | 35 |
| D S U | 17 | 17 | 17 | 18 | 18 | 19 | 21 | 23 | 25 | 26 | 27 | 29 | 30 | 32 | 33 | 35 | 36 | 38 |
| Elima | 19 | 19 | 20 | 20 | 21 | 22 | 23 | 26 | 28 | 29 | 31 | 33 | 34 | 36 | 38 | 40 | 41 | 43 |
| Elkom (S) | 12 | 12 | 12 | 12 | 13 | 13 | 14 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 |
| Other | 506 | 510 | 518 | 531 | 551 | 580 | 622 | 683 | 736 | 779 | 824 | 872 | 914 | 957 | 1,003 | 1,051 | 1,091 | 1,133 |
| **Building Materials** | **993** | **993** | **997** | **1,003** | **1,015** | **1,034** | **1,060** | **1,100** | **1,138** | **1,172** | **1,202** | **1,229** | **1,256** | **1,283** | **1,311** | **1,340** | **1,370** | **1,400** |
| Beloiz. Tsiment | 54 | 54 | 54 | 54 | 55 | 56 | 58 | 60 | 62 | 64 | 65 | 67 | 68 | 70 | 71 | 73 | 74 | 76 |
| Devn. Tsiment | 102 | 102 | 102 | 103 | 104 | 106 | 109 | 113 | 117 | 120 | 123 | 126 | 129 | 132 | 135 | 138 | 141 | 144 |
| Bulkan | 36 | 36 | 37 | 37 | 37 | 38 | 39 | 40 | 42 | 43 | 44 | 45 | 46 | 47 | 48 | 49 | 50 | 51 |
| Izida | 16 | 16 | 16 | 16 | 17 | 17 | 17 | 18 | 19 | 19 | 20 | 20 | 21 | 21 | 21 | 22 | 22 | 23 |
| Pl. Tsiment | 60 | 60 | 60 | 60 | 61 | 62 | 64 | 66 | 68 | 70 | 72 | 74 | 75 | 77 | 79 | 80 | 82 | 84 |
| Zl. Panega | 88 | 88 | 88 | 89 | 90 | 91 | 94 | 97 | 101 | 104 | 106 | 109 | 111 | 113 | 116 | 119 | 121 | 124 |
| Han Asparuh (S) | 16 | 16 | 16 | 16 | 17 | 17 | 17 | 18 | 19 | 19 | 20 | 20 | 21 | 21 | 22 | 22 | 23 | 23 |
| Kaolin (S) | 18 | 18 | 18 | 18 | 18 | 19 | 19 | 20 | 21 | 21 | 22 | 22 | 23 | 23 | 24 | 24 | 25 | 25 |
| Other | 603 | 603 | 605 | 609 | 616 | 628 | 643 | 668 | 691 | 711 | 730 | 746 | 762 | 779 | 796 | 814 | 832 | 850 |

**Exhibit 3–4 (continued)**
**BULGARIA**
**ELECTRICITY DEMAND FORECAST**
**HIGH DEMAND SCENARIO**

**FORECAST OF INDUSTRIAL SALES, GWh/year**

| | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Timber | 269 | 265 | 263 | 263 | 264 | 265 | 268 | 273 | 278 | 283 | 288 | 293 | 299 | 304 | 310 | 315 | 321 | 327 |
| **Pulp & paper, wood products** | **348** | **343** | **340** | **339** | **341** | **343** | **347** | **353** | **360** | **366** | **373** | **379** | **386** | **393** | **400** | **407** | **415** | **422** |
| Rulon–Iskar (S) | 27 | 27 | 26 | 26 | 26 | 27 | 27 | 27 | 28 | 28 | 29 | 29 | 30 | 30 | 31 | 32 | 32 | 33 |
| PHHI | 24 | 23 | 23 | 23 | 23 | 23 | 24 | 24 | 24 | 25 | 25 | 26 | 26 | 27 | 27 | 28 | 28 | 29 |
| TKTSH | 55 | 54 | 54 | 54 | 54 | 54 | 55 | 56 | 57 | 58 | 59 | 60 | 61 | 62 | 63 | 64 | 65 | 67 |
| ZMK (S) | 38 | 37 | 37 | 37 | 37 | 37 | 38 | 38 | 39 | 40 | 41 | 41 | 42 | 43 | 44 | 44 | 45 | 46 |
| Lesil | 17 | 16 | 16 | 16 | 16 | 16 | 16 | 17 | 17 | 17 | 18 | 18 | 18 | 19 | 19 | 19 | 20 | 20 |
| St. Kirajiev (S) | 55 | 54 | 54 | 54 | 54 | 54 | 55 | 56 | 57 | 58 | 59 | 60 | 61 | 62 | 63 | 65 | 66 | 67 |
| TKHTS (S) | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 11 | 11 | 11 | 11 | 11 | 12 | 12 | 12 | 12 | 12 | 13 |
| Other | 123 | 121 | 120 | 120 | 120 | 121 | 122 | 124 | 127 | 129 | 131 | 134 | 136 | 138 | 141 | 143 | 146 | 149 |
| **Glass** | **466** | **470** | **478** | **490** | **509** | **534** | **573** | **630** | **679** | **718** | **760** | **804** | **842** | **883** | **925** | **970** | **1,007** | **1,045** |
| Belopal | 38 | 38 | 39 | 40 | 41 | 43 | 47 | 51 | 55 | 58 | 62 | 65 | 68 | 72 | 75 | 79 | 82 | 85 |
| Kitka | 25 | 25 | 26 | 26 | 27 | 29 | 31 | 34 | 37 | 39 | 41 | 43 | 45 | 48 | 50 | 52 | 54 | 56 |
| Fayans | 26 | 27 | 27 | 28 | 29 | 30 | 32 | 36 | 38 | 41 | 43 | 45 | 48 | 50 | 52 | 55 | 57 | 59 |
| Rubin | 25 | 25 | 26 | 26 | 27 | 29 | 31 | 34 | 36 | 38 | 41 | 43 | 45 | 47 | 50 | 52 | 54 | 56 |
| Drushba | 44 | 44 | 45 | 46 | 48 | 50 | 54 | 59 | 64 | 67 | 71 | 75 | 79 | 83 | 87 | 91 | 94 | 98 |
| Kvarts | 18 | 18 | 19 | 19 | 20 | 21 | 22 | 25 | 27 | 28 | 30 | 31 | 33 | 35 | 36 | 38 | 39 | 41 |
| Diamant (S) | 21 | 21 | 22 | 22 | 23 | 24 | 26 | 28 | 31 | 32 | 34 | 36 | 38 | 40 | 42 | 44 | 45 | 47 |
| Other | 269 | 271 | 276 | 283 | 293 | 308 | 331 | 363 | 392 | 414 | 439 | 464 | 486 | 510 | 534 | 560 | 581 | 603 |
| **Textiles** | **566** | **566** | **568** | **571** | **578** | **589** | **604** | **627** | **648** | **668** | **685** | **700** | **715** | **731** | **747** | **764** | **780** | **798** |
| Manuela | 23 | 23 | 23 | 23 | 24 | 24 | 25 | 25 | 26 | 27 | 28 | 28 | 29 | 30 | 30 | 31 | 32 | 32 |
| Dobruja | 9 | 9 | 9 | 9 | 9 | 9 | 10 | 10 | 10 | 11 | 11 | 11 | 11 | 12 | 12 | 12 | 12 | 13 |
| Sliteks | 21 | 21 | 21 | 21 | 21 | 21 | 22 | 23 | 24 | 24 | 25 | 25 | 26 | 27 | 27 | 28 | 28 | 29 |
| Vratitsa | 14 | 14 | 14 | 14 | 14 | 15 | 15 | 15 | 16 | 16 | 17 | 17 | 18 | 18 | 18 | 19 | 19 | 20 |
| Other | 499 | 499 | 501 | 504 | 510 | 520 | 533 | 553 | 572 | 589 | 604 | 618 | 631 | 645 | 659 | 674 | 689 | 704 |
| **Food & Beverage** | **1,191** | **1,191** | **1,196** | **1,203** | **1,218** | **1,241** | **1,272** | **1,320** | **1,365** | **1,406** | **1,443** | **1,474** | **1,507** | **1,540** | **1,574** | **1,608** | **1,644** | **1,680** |
| N. Vaptsarov | 32 | 32 | 33 | 33 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 | 41 | 42 | 43 | 44 | 45 | 46 |
| Tyot. Kombinat (S) | 11 | 11 | 11 | 11 | 11 | 11 | 12 | 12 | 13 | 13 | 13 | 14 | 14 | 14 | 15 | 15 | 15 | 16 |
| MEZ "Kambana" (S) | 76 | 76 | 76 | 77 | 78 | 79 | 81 | 84 | 87 | 90 | 92 | 94 | 96 | 98 | 100 | 103 | 105 | 107 |
| SKPPPMYA (S) | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 11 | 11 | 12 | 12 | 12 | 12 | 13 | 13 | 13 | 14 | 14 |
| Other | 1,062 | 1,062 | 1,066 | 1,073 | 1,086 | 1,106 | 1,134 | 1,177 | 1,217 | 1,254 | 1,286 | 1,314 | 1,343 | 1,373 | 1,403 | 1,434 | 1,465 | 1,498 |
| **Other Industries** | **911** | **911** | **914** | **920** | **931** | **949** | **972** | **1,009** | **1,044** | **1,075** | **1,103** | **1,127** | **1,152** | **1,177** | **1,203** | **1,230** | **1,257** | **1,284** |
| Bules (S) | 14 | 14 | 14 | 14 | 14 | 14 | 15 | 15 | 16 | 16 | 16 | 17 | 17 | 18 | 18 | 18 | 19 | 19 |
| Cherno More (S) | 9 | 9 | 9 | 9 | 10 | 10 | 10 | 10 | 11 | 11 | 11 | 12 | 12 | 12 | 12 | 13 | 13 | 13 |
| Construction | 687 | 687 | 690 | 694 | 702 | 716 | 734 | 762 | 787 | 811 | 832 | 851 | 869 | 888 | 908 | 928 | 948 | 969 |
| Agriculture | 910 | 956 | 1,007 | 1,054 | 1,094 | 1,128 | 1,153 | 1,174 | 1,195 | 1,217 | 1,239 | 1,261 | 1,284 | 1,307 | 1,330 | 1,354 | 1,379 | 1,404 |
| Transport & Communications | 1,450 | 1,523 | 1,605 | 1,695 | 1,776 | 1,849 | 1,910 | 1,963 | 2,018 | 2,055 | 2,092 | 2,129 | 2,168 | 2,207 | 2,246 | 2,287 | 2,328 | 2,370 |
| Public Sector | 3,097 | 3,159 | 3,235 | 3,287 | 3,346 | 3,383 | 3,427 | 3,489 | 3,551 | 3,615 | 3,680 | 3,747 | 3,814 | 3,883 | 3,953 | 4,024 | 4,096 | 4,170 |

HIGH_IND.WK1

## 3.5 COMPARISON OF DEMAND FORECASTS

These three scenarios are compared in a series of graphs. Each graph also shows the historical situation since 1975, for clarity.

- Exhibit 3-5 shows that the demand for electricity in the household sector increases steadily for all cases.

- Exhibit 3-6 illustrates industrial demand. In no case does industrial energy consumption reach historical maximums.

- Electricity demand in other sectors is given in Exhibit 3-7. Growth in demand is low, except in the case of high economic growth.

- A comparison of the changes in the total domestic sales of electricity are provided in Exhibit 3-8. In year 2000, the high scenario has a 15% greater level of electricity demand than the low scenario.

- Gross total electricity demand, including power plant auxiliaries and distribution losses, is shown in Exhibit 3-9.

  Referring back to Exhibit 3-1, it can be seen that all three scenarios fall within the band of projections by other forecasters.

- Annual maximum peak demand is illustrated in Exhibit 3-10, and shows a different pattern, consistent with the economic restructuring away from heavy industry.



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Exhibit 3-5

# Bulgaria - Household Electricity Demand

Comparison of Scenarios

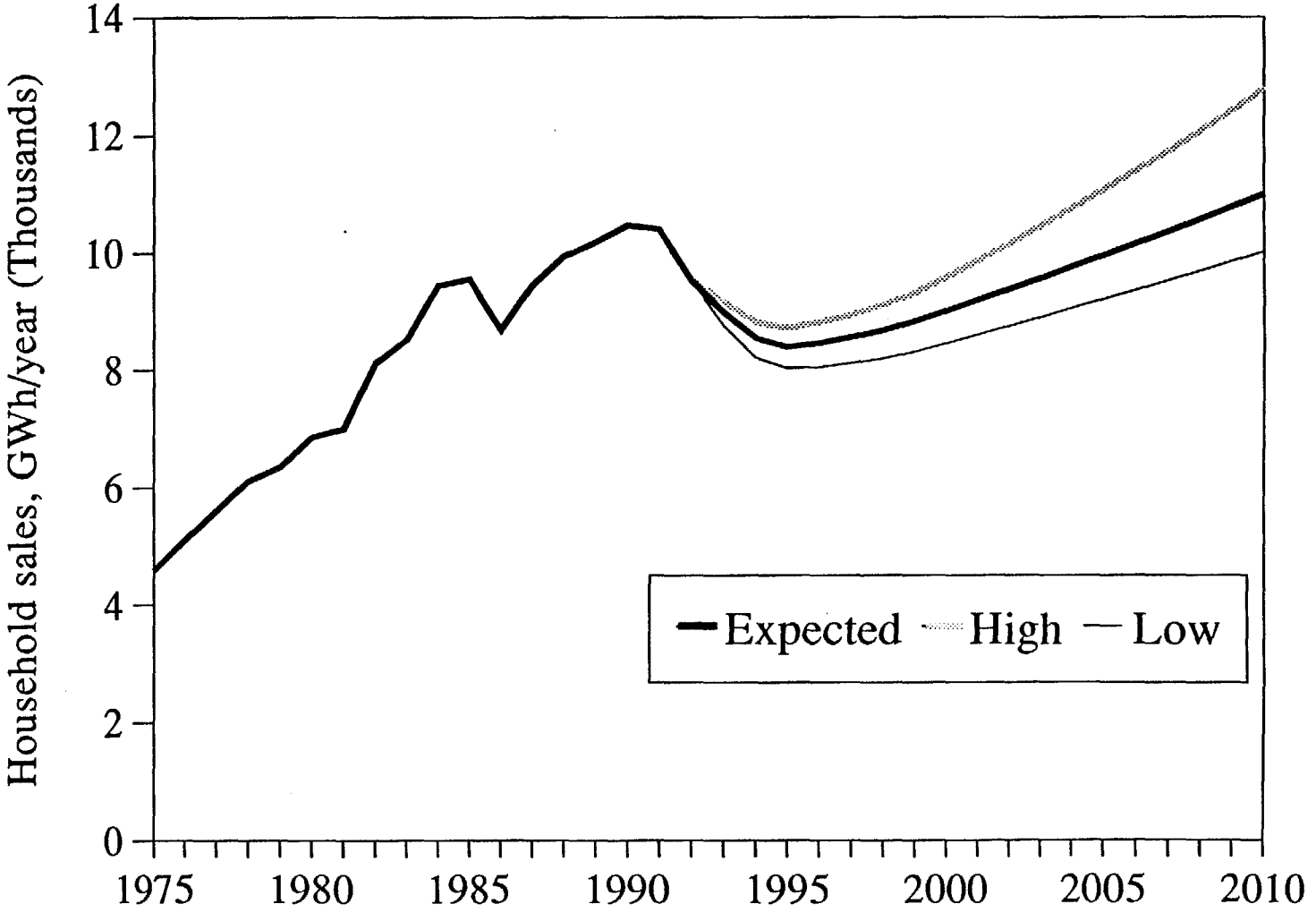


Exhibit 3-6

# Bulgaria - Industry Electricity Demand

Comparison of Scenarios

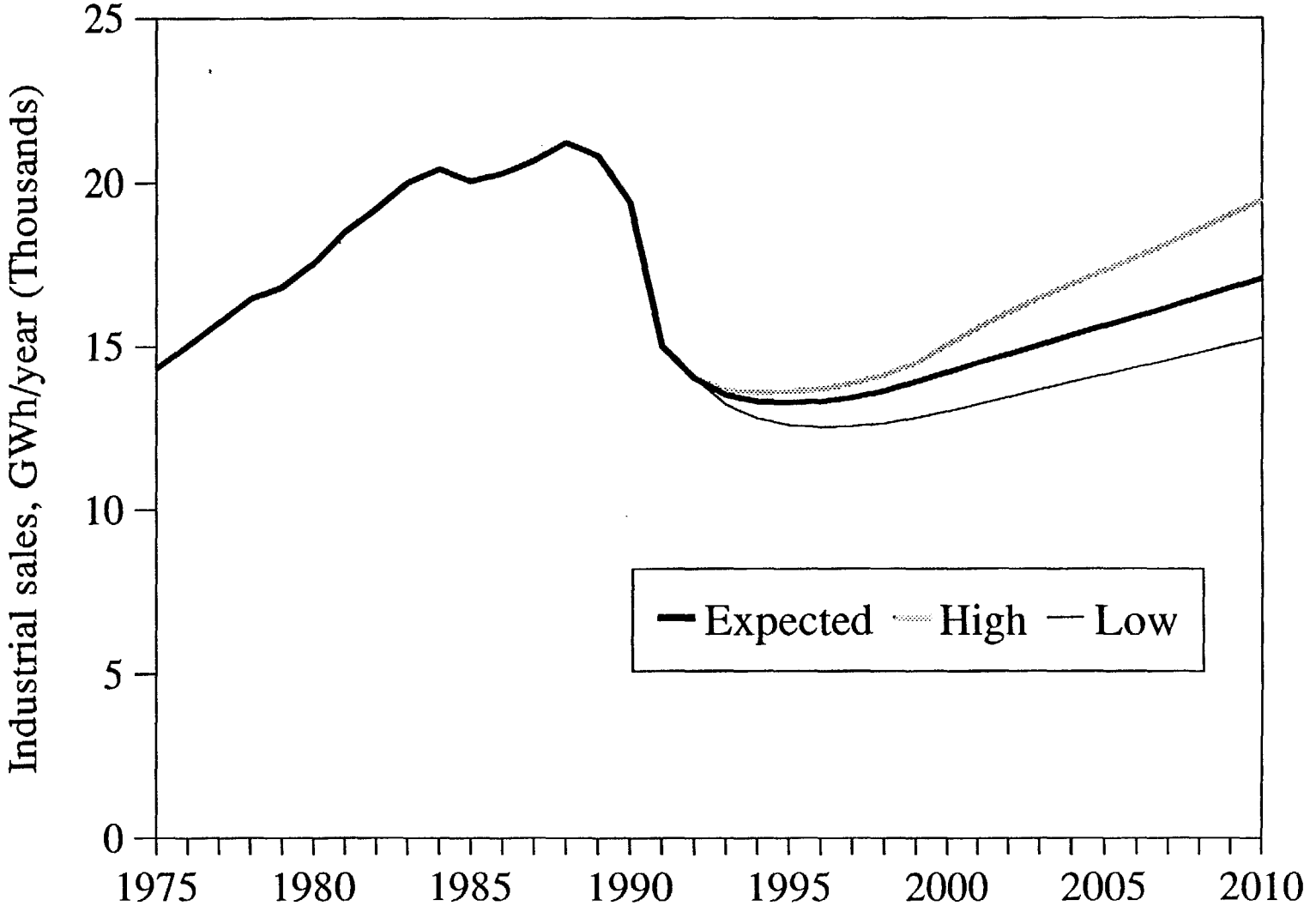


Exhibit 3-7

# Bulgaria - Other Electricity Demand

Comparison of Scenarios

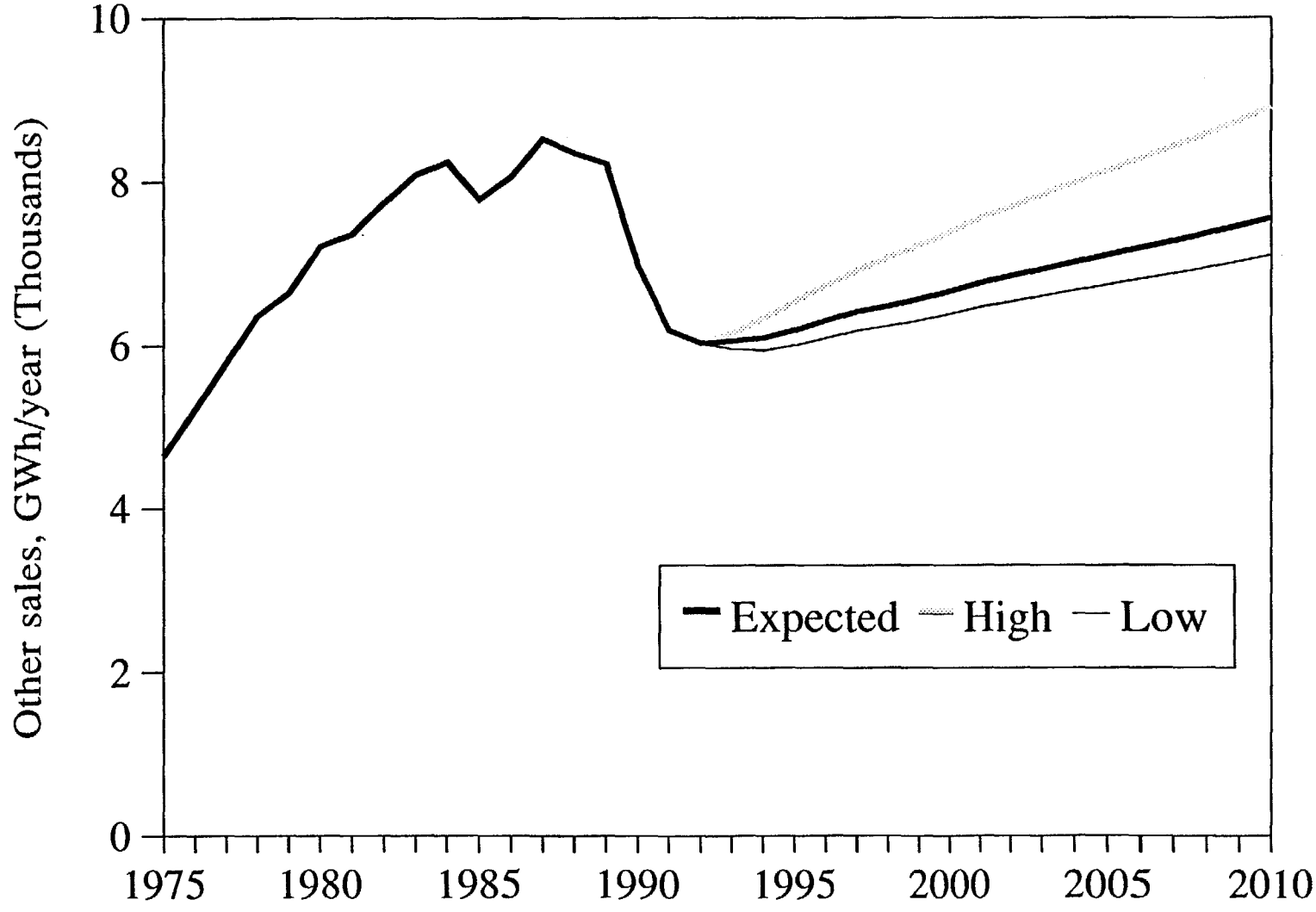


Exhibit 3-8

# Bulgaria - Total Domestic Sales

Comparison of Scenarios

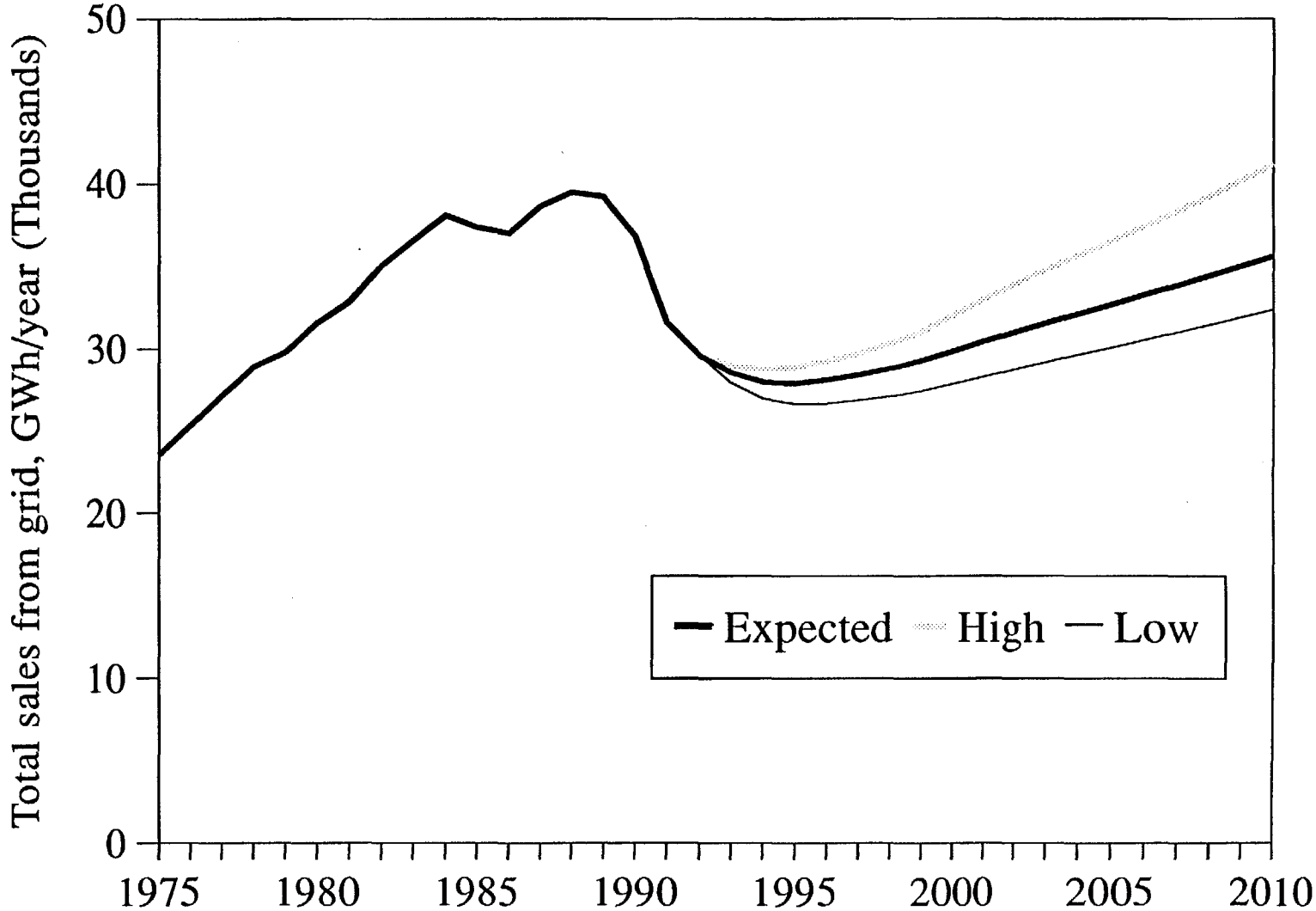


Exhibit 3-9

# Bulgaria - Total Electricity Demand

Comparison of Scenarios

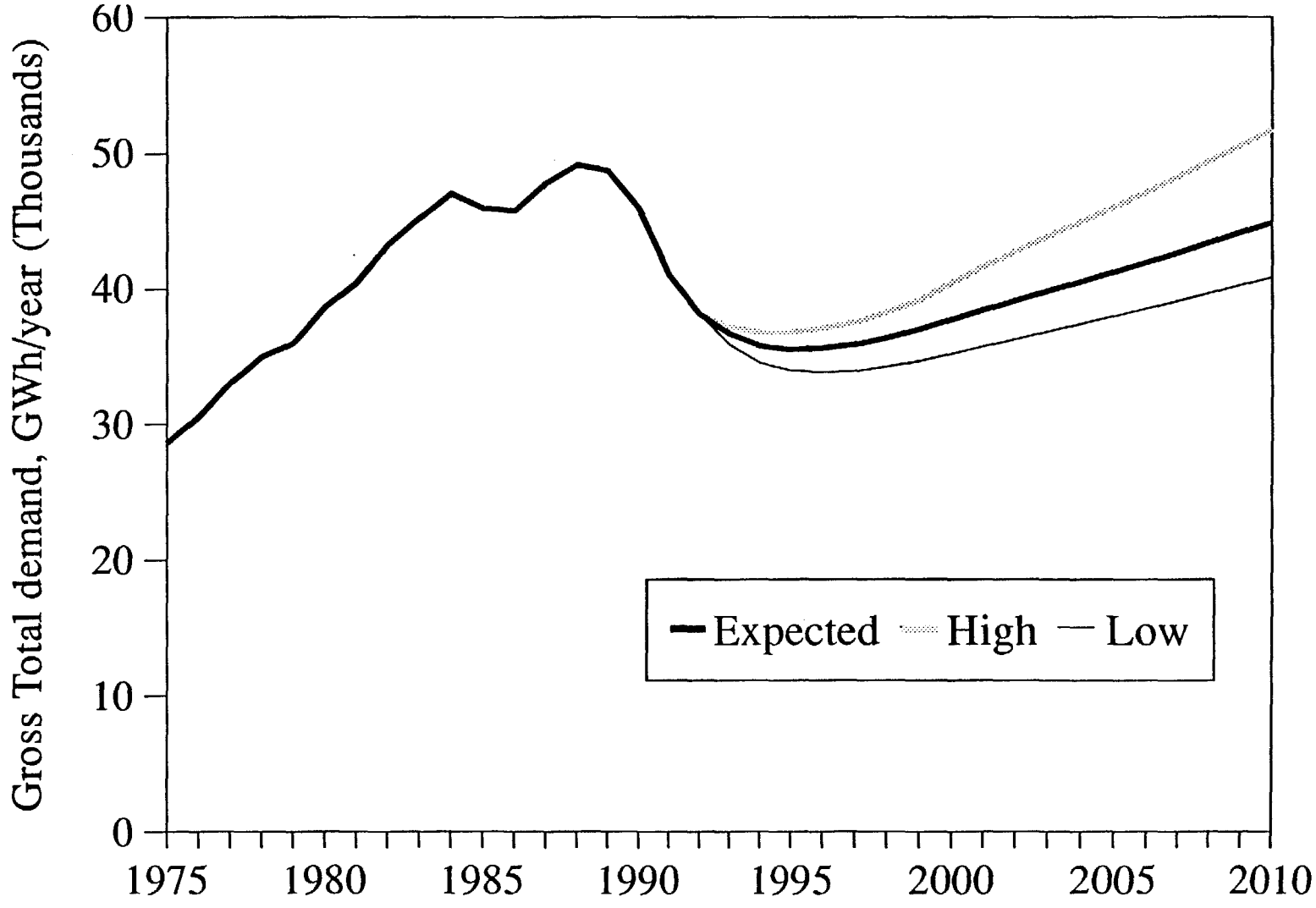
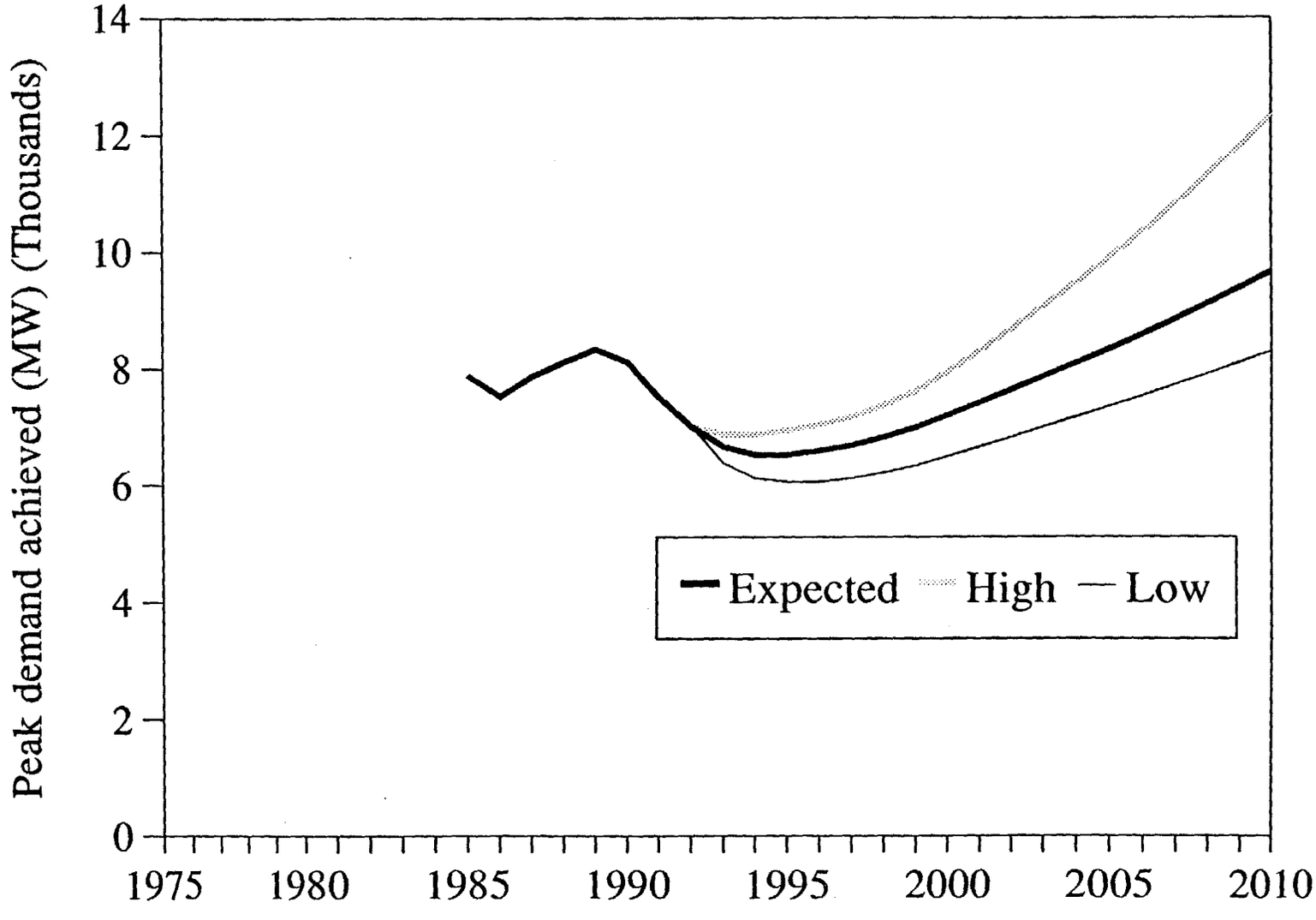


Exhibit 3-10

**Bulgaria - Annual Peak Demand**

Comparison of Scenarios



# INDEPENDENT POWER GENERATION IN BULGARIA: ASSESSMENT OF POTENTIAL, IMPEDIMENTS, AND OPTIONS

*Prepared for*:

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August 1993

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10) Prepare Terms for Large Power Contracts

**Appendix A** Map of Bulgaria Power System

**Appendix B** Statistics on Major Power Project Rehabilitation and Repowering Opportunities in Bulgaria

**Appendix C** Standard Power Purchase Contract Between NEK and District Heating or Industrial Cogenerators



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## List of Acronyms

| | |
|---|---|
| ADB | The Asian Development Bank |
| AyE | Agua y Energia Electrica (Argentina) |
| BLT | Build, Lease, and Transfer |
| BOO | Build, Own, and Operate |
| BOOT or BOT | Build, Own, Operate and Transfer |
| CAMME | The Compania Administradora del Mercado Mayorista Electrico (Argentina) |
| CDC | The Commonwealth Development Corporation |
| CMEA | The Council of Mutual Economic Assistance |
| CNEA | The National Atomic energy Commission (Argentina) |
| COE | The Committee of Energy |
| COM | The Council of Ministers |
| COP | The Commission on Prices |
| EBRD | The European Bank for Reconstruction and Development |
| EC | European Community |
| "EEE" | An Evaluation of the Effect on the Environment |
| ENDESA | Empresa Nacional de Electricidad (Spain) |
| ENRE | The Ente Nacional Regulador de la Electricidad (Argentina) |
| EWG | Electricity Wholesale Generators (EWG) |
| EX-IM | US Export Import Bank |
| FERC | The Federal Energy Regulatory Commission |
| FSU | The former Soviet Union |
| GOB | Government of Bulgaria |
| HIDRONOR | Hidroelectrica Norpatagonica (Argentina) |
| IFC | The International Finance Corporation |
| IMF | International Monetary Fund |
| INI | Instituto Nacional de Industria (Spain) |
| IRP | Integrated Resource Planning |
| IPP | Independent Power Producers |
| MIE | The Ministerio de Industria y Energia (Spain) |
| MLC | The Municipal Land Commission |
| MOE | The Ministry of Environment |
| MOF | The Ministry of Finance |
| NCW | National Council on Water |
| NEK | The Natsionalna Elektricheska Kompania |
| NPC | National Power Corporation (Philippines) |
| OPIC | US Overseas Private Investment Corporation |
| PUHCA | Public Utility Holding Company Act |
| PURPA | The Public Utility Regulatory Policies Act of 1978 |
| QFs | qualified facilities |

| | |
|---|---|
| REDESA | Red Electrica (Spain) |
| SAL | Structural Adjustment Loan |
| SE | The Secretariat of Energy (Argentina) |
| SEGBA | Servicios Electricos del Gran Buenos Aires (Argentina) |
| SIN | Sistema Interconectado Nacional (Argentina) |
| T&D | Transmission and Distribution |
| TDA | US Trade and Development Agency |
| TPA | Third Party Access |
| UEFSA | Union Fenosa (Spain) |
| UNESA | The Unidad Electrica, SA (Spain) |
| WEM | The Wholesale Electric Market (Argentina) |
| WASP | Wien Automated System Planning Package |

# I EXECUTIVE SUMMARY

Assessing the potential impediments and options for independent power in Bulgaria requires reviewing the international experience, evaluating the local independent power market potential, examining the existing policy, regulatory, and institutional conditions, and suggesting approaches to policy and institutional development.

## 1) The International Experience with Independent Power

Independent power production, or the privately-financed and central utility-independent generation of power, has become a rapidly expanding industry not only in the United States but in many countries in Asia, Latin America, and Europe. In 1992, independent power contributed 62% (or 3,848 MW) of all new capacity additions in the United States. As of 1991, there were about 3,000 independent power projects in the U.S. totaling more than 40,000 MW. It is estimated that of the 542 GW of capacity additions planned in 131 non-North American countries between 1993 and 2000, independent power projects could claim between 80 and 115 GW. The economic and financial advantages of independent power are the driving force behind this expanding new industry: access to private capital, minimized costs due to competition, shift of project risk to the private sector, more rapid integration of optimal power technologies, and expanded use of renewable energy and cogeneration.

The international experience (e.g. in such countries as Poland, Argentina, and Spain) with developing an independent power market provides lessons that should be considered in Bulgaria. As the experience in the United States and emerging economies has shown, the process of attracting private capital into the power sector essentially involves the reduction and management of both country and project risks. The Bulgarian government, the Committee of Energy (COE), and the electric utility (NEK) will have to play an active role in reducing and controlling those risks that a private investor and developer cannot control. Establishing key elements of the policy, institutional, and regulatory framework for independent power plays an important role in the risk mitigation and management process. The contractual commitments that the Government and NEK are willing to offer to private developers are also critical to attracting private financing, because they also reduce the investor's exposure to risk. Ultimately, a private developer and investor must be assured through the policy and contractual framework that NEK is offering a fair power purchase price under fair contractual terms and that the process of selecting a developer will also be fair and transparent.

The international financing of independent power involves structuring and managing both country and project risks in a way that is competitive regionally and globally. Given the current high level of country risk and the lack of a developed capital market in Bulgaria, power projects with international participation will initially require a major role for the multilateral and bilateral financial institutions and a Bulgarian government guarantee of utility



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performance. For instance, the European Bank for Reconstruction and Development (EBRD), the World Bank, the International Finance Corporation (IFC), export credit agencies (e.g. US Export Import Bank (EX-IM) or the US Overseas Private Investment Corporation (OPIC)), equipment vendors, and to a small extent, commercial banks could supply the debt financing. The equity investment would come from the foreign investor/developer, a local Bulgarian partner, equipment manufacturers, and possibly the EBRD and IFC. As Bulgaria's independent power market matures and NEK's creditworthiness improves, the need for multilateral and bilateral support and government guarantees will diminish.

## 2) Independent Power Market Potential in Bulgaria

Independent power in Bulgaria faces clear barriers that will complicate the process of attracting private capital in the power sector:

- Difficult economic structural adjustments: Bulgaria's economic output has experienced a major decline as it tries to make the transition from central planning and communist block markets to free enterprise and international markets.

- Declining power demand and unreliable capacity: The demand for power has also declined leaving surplus capacity, with much of this capacity being unreliable and in considerable need of reconditioning.

- Poor utility financial performance: Electricity tariffs on average still do not reflect the full costs of generation, transmission, and distribution; as a result the electric utility (NEK) is currently not a financially-sound institution.

- Inadequate policy and institutional framework: The policy and institutional framework for independent power is not in place and the legal framework for private investment still requires further modifications.

- High level of commercial risks: Bulgaria is facing high inflation, high interest rates, major unemployment, and unresolved commercial debt negotiations such that most private investors and lenders will be unwilling to make the long-term investment needed by the power sector.

Despite these challenges, various positive conditions and trends in Bulgaria could encourage independent power generation in the coming years:

- Economic adjustment developments: Bulgaria's economic distortions and commercial risks are gradually being reduced through the structural-adjustment loans of the World Bank and International Monetary Fund (IMF) and commercial bank debt negotiations.



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- Electric utility financial improvements: NEK is raising its tariffs to reflect the full costs of generation, transmission, and distribution and expects to be financially viable by 1995.

- Foreign investment laws instituted: Bulgaria has enacted laws that establish far reaching rights for private investors, including 100% foreign ownership, national treatment of foreign firms, and free repatriation of profits.

- Investment opportunities in existing capacity: There is a definite need for private investment to rehabilitate or repower existing power plants and cogeneration facilities.

- New capacity needs: When Bulgaria's economy begins to grow again, additional capacity will be needed, including thermal and hydro power plants.

- Independent power policy formulation: The Government has expressed a commitment to encouraging independent power and has begun the process of developing the necessary policy and institutional framework.

Recognizing the difficult economic conditions, sources of financing can be found if the policy and project framework is properly structured. The key components for developing a viable independent power program in Bulgaria will involve two parallel activities: policy development and project development, as discussed below.

Attractive power project development opportunities exist in Bulgaria in various sectors. While Bulgaria has an installed capacity of 12,074 MW, over the last several years the utility, NEK, has had difficulty meeting a system peak of 7,200 MW. This poor performance has been due to aging or technologically-outdated power plants and unreliable supplies of coal. There is a major need for investment to rehabilitate or repower the existing central power and industrial and district heating cogeneration plants. In addition, as power demand increases in the coming decade, major opportunities for building new thermal and hydro power plants will exist. Potential power projects that could attract foreign investors and a preliminary market estimate include:

- Industrial Cogeneration: Rehabilitating one or more major industrial cogeneration projects, such as Chimco Vratsa, Burgas, Vidin, or Kremikovtzi; [600 MW - 2,600 MW]

- District Heating Cogeneration: Rehabilitating one or more of the major district heating plants, such as Sofia or Pernik; [600 MW - 2,500 MW]

- Hydro Power: Private development of one or more of the mini or major hydro sites, such as the sites at Gorna Arda or Sredna Vacha. [400 MW - 2,600 MW]

- Coal-Fired Power Plants: Rehabilitating one or more of the existing coal-fired power plants, such as Maritsa East 1, 2, or 3, Varna, or Russe; [200 MW - 4,500 MW]



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- New Generation: Construction of a new combined cycle gas or coal-fired power plant. [1993 - 2000: ~ 880 MW (assuming the intermediate demand growth scenario)]

Feasibility analysis of some of these projects is already underway, and an initial priority ranking of these projects will be included in the least-cost plan that is currently under development.

### 3) Existing Policy, Regulatory, and Institutional Conditions

The existing policy and institutional framework in Bulgaria is undergoing major changes. Only one statute, the Law on the Environment, has any significant implementing regulations. The power sector regulatory institution is also in a formative stage. The prospects for a broad independent power program will be greatly enhanced as Bulgaria's policy and institutional framework becomes more developed. The key power sector issues that need to be addressed are:

- Energy Legislation: There currently is no comprehensive energy law that addresses the rights of independent generators. A Law on Electrical Energy is being drafted that appears favorable to independent power, however, this Law has yet to be approved by the Parliament.

- Implementing Regulations: Once the Law on Electrical Energy is passed, implementing regulations clearly defining the Law will need to be drafted. These regulations could play an important role in defining such issues as power pricing, project solicitation, etc.

- Legal Recourse: The extent to which there is a reliable system of legal recourse in Bulgaria will also affect the attractiveness of investing Bulgarian power projects. It may be necessary for all parties to an independent power contract to submit to binding dispute resolution by an independent third party, which can be implemented in Bulgaria or in a foreign country.

- Institutional Priorities: An institutional structure and policy favorable to independent power is only beginning to emerge at COE and NEK. There is a need to set specific objectives for COE and NEK against which actual progress can be measured. Other ministries with an important role in power project approval, such as the Ministry of Environment, need to be included in the process in a complementary manner.

- Project Review Process: At present, there is not a clear project approval process that an independent developer can understand and follow. The procedure for project prioritization, selection, negotiation, and permitting will need further definition.



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A preliminary assessment of the power sector institutions and the energy bill currently being drafted indicates that a potentially favorable policy and institutional framework is under development.

### 4) Suggested Approaches to the Introduction of a Policy and Institutional Framework for Independent Power

The Government of Bulgaria, the Committee of Energy (COE), and NEK will need to continue their progress in establishing the necessary policy, regulatory, and institutional framework for independent power. Some of the necessary activities are already underway, particularly electricity pricing reform, energy legislation, Integrated Resource Planning (IRP) analysis, and project feasibility assessments. Additional suggestions are summarized below:

- Strengthen Legislation: Strengthen components of energy and foreign investment legislation to facilitate independent power;
- Establish Regulatory Institution: Establish an independent regulatory institution that addresses independent power and ensure staffing by qualified regulators;
- Draft Regulations: Develop and publish detailed regulations based on the energy law;
- Establish Information Clearinghouse: Establish a central information clearinghouse for Independent Power (IPP) developers;
- Implement Integrated Resource Planning: Use Integrated Resource Planning to establish long run marginal cost and power purchase pricing to guide project selection;
- Define Government Guarantees and Incentives Offered: Establish consistent policy regarding government incentives and guarantees covering utility performance, fuel supply, etc.;
- Define Solicitation Process: Establish the procedure for soliciting independent power;
- Train Negotiations Team: Establish and train a multi-disciplinary review and negotiation team;
- Prepare Standard Small Power Contracts: Provide standard offer contracts for small renewable and cogeneration projects;
- Prepare Terms for Large Power Contracts: Provide standard non-price terms for large projects.



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While all elements of the policy and institutional framework described above are necessary in order to enable an active long term independent power market, not all components are essential to develop the initial projects. Independent power projects can potentially move forward in an incomplete policy and institutional f[illegible]work. In fact, experience in other countries (such as the Philippines, Poland, and Arg[illegible]as shown that promoting specific projects early on can in fact help refine the policy de[illegible]ment process.

In order to implement a parallel policy and project development strategy, certain priority elements of the policy and institutional framework need to be developed early on in order to ensure that any proposed independent power projects have an adequate institutional and contractual framework. The near-term key power sector policy framework that needs to be implemented includes the following elements from the above list: establish a consistent policy regarding government guarantees and incentives; establish and train a multi-disciplinary review and negotiation team within NEK, and provide standard non-price terms for large, central, hydro, or cogeneration projects. It may be desirable to also prepare standard offer contracts for small renewable and cogeneration projects. With these basic elements in place, it should be possible to attract independent power investments.



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# II THE INTERNATIONAL EXPERIENCE WITH INDEPENDENT POWER

## 1) The Definition of Independent Power

### a) Basic Legal and Financial Structure

Independent power represents the financing, construction, and operation of a power generating facility by a company that is independent from the central power purchasing electric utility. The central utility can either be private or government owned, but in both cases is a regulated monopoly. The independent power generator is usually owned by a private company. It is typically an unregulated facility that enters into a clearly-defined power purchase agreement with the utility. By this definition, Bulgaria already has various examples of independent industrial cogeneration and district heating plants at government-owned corporations.

An independent power project (IPP) can: (1) exclusively serve the captive power needs of a particular factory or load (thereby reducing the power requirements of the central utility); (2) meet captive power needs and also generate surplus power and energy for sale to the grid; or (3) be a dedicated power plant for bulk power sales to the grid. Categories 1 and 2 involve some form of cogeneration while category 3 include central power plants ranging in scale from small decentralized generators (e.g. mini-hydro, geothermal, wind, solar, etc.) to large power plants (e.g. coal, oil, gas fired units).

IPPs can be introduced in different ways. At one end of the spectrum, independent power has involved a major restructuring of the power sector, the breakup of generation, transmission, and distribution, and the sale of government-owned power generation and distribution assets to the private sector (as for instance has been implemented in the United Kingdom and Argentina). At the other end of the spectrum, some countries have retained government-control over the main generation, transmission, and distribution system, and have simply entered into power purchase agreements with selected independent power generators (as has been implemented in the Philippines and Spain). Given Bulgaria's expressed near-term requirement to work with the existing government utility, NEK, and the clear objective to attract private capital into the power sector, the focus of this report will be on the latter model for independent power.

Privately financed IPPs are structured as separate companies that involve limited or non-recourse project financing. This method serves to mobilize private capital more effectively by limiting the liabilities of the project owners. In the event of default or bankruptcy, the lenders and investors have no right to the assets of the owners of the company; the only collateral they have is in the assets of the specific project company. As a result, however, lenders require more assurances in the form of contractual agreements, including iron-clad power purchase contracts, and attractive internal rates of return before they are willing to lend to independent power projects.



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### b) The Process of Independent Power Project Development

The life of an independent power project involves three major phases: development, construction, and operation. Within these phases, some ten distinct steps can be defined.

(1) The electric utility determines the amount and type of capacity needed in its expansion plan through a planning process;

(2) the electric utility obtains and evaluates proposals from prospective developers that are either unsolicited or solicited through a competitive bidding process;

(3) The utility and developer may decide to negotiate an initial letter of intent or memorandum of understanding to define the basic parameters of the proposed project;

(4) The developer performs a detailed feasibility study to define the precise technical and economic characteristics of project;

(5) Detailed legal agreements are negotiated for the purchase of power, fuel supply, construction services, operation & maintenance, etc.;

(6) The developer proceeds to obtain all the necessary permits required, including such issues as land use, environmental emissions, taxes, etc;

(7) Short-term and long-term debt and equity financing is obtained for both construction and long-term capital requirements;

(8) A detailed engineering design of the project is completed;

(9) The power plant is constructed or rehabilitated and commissioned;

(10) The plant is operated, the debt is serviced, and the equity investors earn their return.

Each of these steps represent a milestone or hurdle in the process of developing the independent power project. As shown in Figure 1, at each stage of this process the costs of developing the project increase while the risks of the project failing decrease.



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# Private Power Project Development Risk and Cost Phases

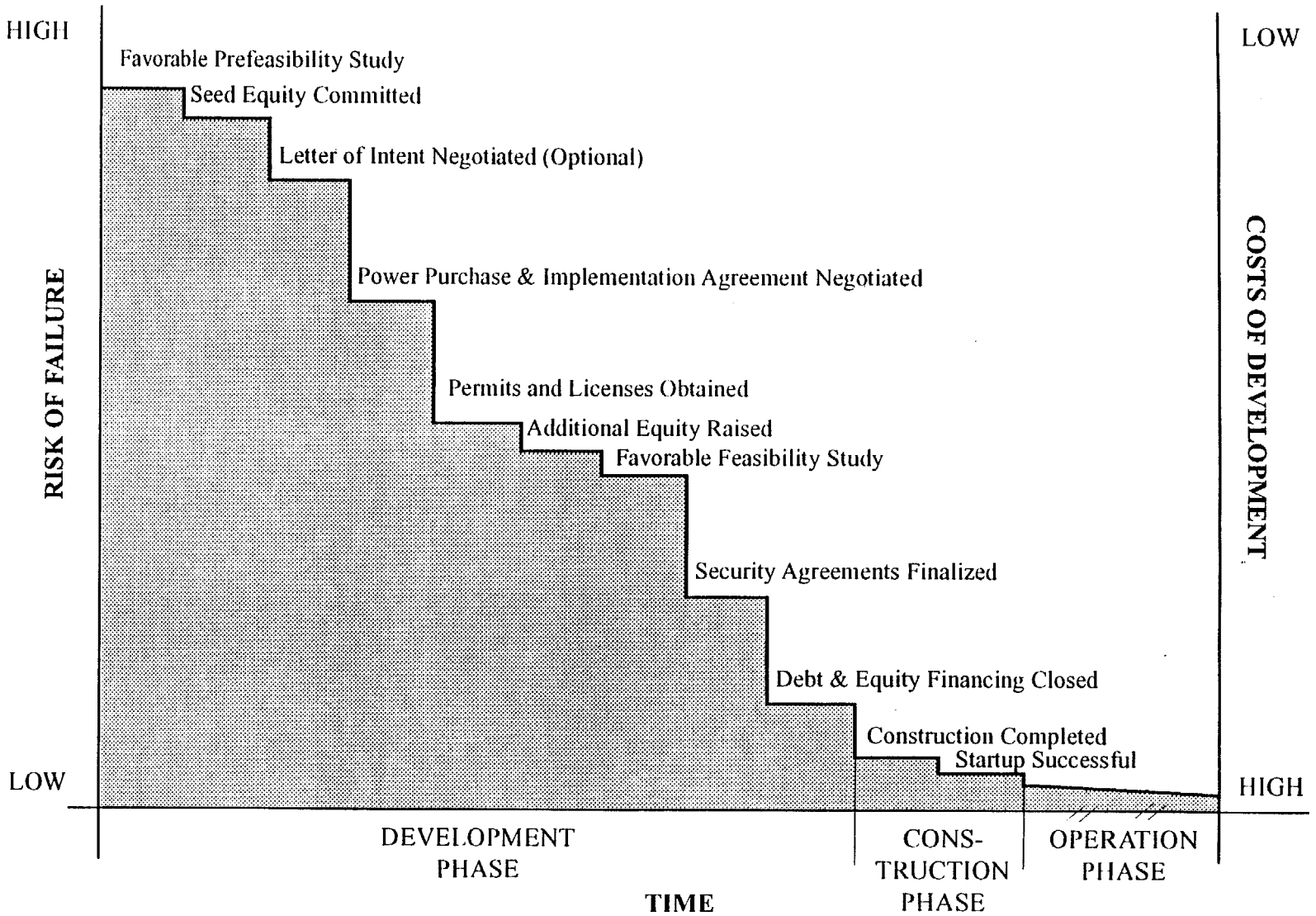


Figure 1

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## 2) The Evolution of Independent Power in the United States

### a) Introduction

The U.S. power sector is characterized by a wide array of players, including investor-owned or private utilities, state and municipal utilities, cooperatives, and Federal utilities. Investor-owned utilities provide most of the electric power generated in the U.S., focusing on sales to ultimate customers and secondly on bulk power sales. Federal utilities, on the other hand, focus on bulk power sales to utilities.

The U.S. power sector is regulated at two levels. The Federal Energy Regulatory Commission (FERC) regulates the federal level, while state public utility commissions in each of the 50 states regulate the state level. FERC has the responsibility to administer federal laws affecting the electric as well as the gas industry and the transfer of these energy supplies across state borders. The public utility commissions in each state has responsibility for regulating, among many items, the prices of retail sales by electric utilities. There are, in addition, 2,000 local entities which regulate pricing and resource use issues affecting municipal power authorities. In total, there are about 2,050 regulatory entities affecting, in one way or another, the actions of over 3,200 electric utilities.

The Public Utility Regulatory Policies Act of 1978 (PURPA) has had a dramatic impact on the US power sector. The statistics speak for themselves. Over the last ten years after the passage of PURPA, close to 2,500 non-utility projects with a total capacity over 30,000 MW came into operation in the United States. In the next ten years, another 55,000 MW of non-utility power generation could come on line, providing over 40% of all new capacity additions before the end of the century. PURPA allowed non-utilities to invest in qualified facilities (QFs) using cogeneration or select renewable or waste fuels. At this point, over 100 non-utility companies are actively involved in this form of private power generation. In fact, some of these companies are utility subsidiaries because the Congress of the United States allowed utilities to own up to 50% of any QF project, as a quid pro quo for opening the door to non-utilities. The story of how this revolution in the power sector evolved is worth exploring to draw lessons for the development of independent power in Bulgaria.

### b) The History of PURPA and Non-Utility Generation

In the late 1970s, the U.S. Government was faced by the energy crisis resulting from the oil price shocks. In an effort to reduce oil imports by eliminating energy waste and promoting the use of indigenous energy sources, PURPA was passed in 1978. The specific objective of this law was to promote the non-utility development of cogeneration and renewable sources of energy. While primarily aimed at fostering energy conservation, PURPA



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also put an end to the power generation monopoly of US utilities and opened the door to the de-regulation of that sector.

Prior to PURPA, no unregulated plant could sell power to the grid. The only non-utility-owned power plants were self-generation facilities generally concentrated in chemical production complexes, pulp and paper mills, and some steel mills. These projects produced power for themselves and did not interface with the grid, except in emergency situations. About 7,000 MW of self-generation was in place prior to PURPA, including nearly 5,000 MW of gas-fired or coal-fired capacity; the balance consisted of mostly black liquor units in pulp and paper mills.

PURPA stipulated two conditions that opened up the US power generation sector:

- **First**, it allowed non-utilities (e.g., private companies, equipment suppliers, construction firms) to build and operate certain types of qualifying facilities (QFs) and sell their power output to the grid without being regulated as a conventional utilities.

- **Second**, it required utilities to buy the power from these QFs under certain price conditions.

**First**, PURPA explicitly exempted QF owners from the regulatory requirements of the Public Utility Holding Company Act (PUHCA). QF owners thereby escaped the burdensome regulatory, reporting, legal, and accounting requirements of PUHCA. Furthermore, QFs were exempted from the rate regulation and other financial reporting regulations of the Federal Power Act. Finally, PURPA exempted QFs from the financial and organizational requirements of the state public utility commissions. These special rights granted to QF owners allowed them to earn an unregulated return on their projects, in contrast to utilities that were subject to rates of returns set by their state public utility commissions.

PURPA allowed non-utilities to build two types of QFs designed to either use an energy-efficient technology (i.e. cogeneration) or help diversify the US power generation mix:

- Cogeneration Projects which simultaneously produce two or more useful forms of energy (process steam, hot water, or process heat) and electricity. Cogeneration projects are energy-efficient since they generate electricity on the margin for as little as 4,000 to 6,500 btu/kWh compared to 9,500 Btu/kWh for a conventional power plant. To qualify as a QF, a cogeneration project must produce at least 5% of its total energy output in the form of useful thermal energy. If that requirement is met, a QF cogeneration project can be of any size and can use any type of fuel.

- Small power projects which produce only electricity but use waste fuels (for example, waste coal, industrial process wastes, or biomass) or renewable energy (for example, geothermal energy, wind power, hydropower or solar energy). To qualify as a QF, a small power project must be below 80 MW.



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**Second,** PURPA stipulated that utilities had to buy the power produced by QFs and had to provide non-discriminatory interconnection and back-up service to these QFs. QFs generally sell power under long-term (20 to 25 year) contracts at rates negotiated or competitively bid with utilities and in compliance with avoided cost and other requirements of relevant state regulatory agencies. The approval of the power sale contract and the normal siting and permitting approvals are generally the only extent to which QFs are regulated. As a quid pro quo for "opening up" the power generation monopoly that electric utilities had, PURPA allowed utilities to own up to 50% of QFs provided they did contract to sell power to themselves.

### c) The Implementation of PURPA

Several implementation issues quickly arose which had to be dealt with both at the Federal level and at the local level:

- At the Federal level, the Federal Energy Regulatory Commission (FERC) was put in charge of the broad implementation of PURPA and, as such, issued in February 1980 its Order 69. This order, however, left a lot of details to state public utility commissions.

- At the state level, public utility commissions retained jurisdiction over the implementation of PURPA, including deciding:

  - the methodology to be used to set rates for sales and purchases of QF-power;
  - the responsibilities for QF interconnections;
  - the standards for QF system safety and reliability; and
  - the process by which these commissions would resolve disputes between utilities and QF owners.

Nonetheless, some states still felt that PURPA was one more instance of Federal interference. The State of Mississippi challenged the constitutionality of the new law in April 1979. It was not until June 1982 that the Supreme Court of the United States ruled that PURPA was constitutional. Consequently, there was little QF market development between 1978 and 1983.

The most important issue, then, became how to determine the price that utilities should pay for QF power. PURPA just said that utilities should pay no more than their "avoided-cost", a new and vague concept which FERC clarified by stating that the avoided cost should be "an administratively-determined approximation of the incremental costs to an electric utility of electric energy and capacity or both, which, but for the purchase from QFs, such utility would generate itself or purchase from another source." At first, this was interpreted to mean the full marginal cost of building the next power plant, which was generally construed as a large,



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expensive, utility-owned power plant. In some cases, this meant paying 10-11 cents/kWh of QF power -- almost twice what utilities would pay for power bought from neighboring utilities.

Although some utilities challenged FERC's "administrative" interpretation, the Supreme Court upheld FERC's authority to endorse the avoided cost approach, stating that the "basic purpose of ....PURPA was to increase the utilization of cogeneration ... and to reduce reliance on fossil fuels" and that "at this early stage of implementation of PURPA, it was reasonable for FERC to prescribe the maximum rate authorized by Congress and thereby provide the maximum incentive for the development of cogeneration and small power production."

Even upheld, the FERC guidelines remained unclear and state commissions developed different methodologies which in some cases were legally challenged as well. For example, New York State declared that there should be a floor of 6 cents per kWh for QF power, a decision which was later repealed. Several states (e.g. Pennsylvania) also said that contracts signed between utilities and QFs were to approved even if they did not quite follow the commission guidelines. Commissions also reacted at different speeds as they faced various utilities with diverse demand and supply situations and different levels of sophistication. In addition, some state commissions (e.g., California and Ohio) had large staffs while others did not have the in-house engineering and financial expertise needed to administer PURPA issues. As a result, only 16 states had issued their regulations by March 1981, the deadline set by FERC. By March 1983, two years later, six states still had no PURPA regulations in place.

While regulators were searching for the best approach, most US utilities were resisting non-utility generation because they resented having to purchase high-priced power from QFs that could be located anywhere and operated by anybody. For most utilities, this smacked of anarchy and, in numerous instances, utilities counteracted by offering discount rates or deferral agreements to industries that were potential cogenerators or by imposing high standby and interconnection rates.

Finally, the pressure of state regulators and the activism of non-utility companies overcame the utilities's opposition in some key states such as California, Texas and Pennsylvania. In these states, non-utility offers started to pour in on a "first-come, first served" basis to take advantage of high-avoided costs. In addition, QFs built then could be amortized over a 5 year period as the result of a new tax law passed under the first term of the Reagan administration. By the mid-1980s, some of these states were swamped by QF offers. For example, over 6,000 MW of offers were signed up in California alone in 1984 and 1985. At that point, utilities and regulators started to search for ways to regain control of the situation by reducing the amount of QF capacity offered with queuing systems and capacity auctions. In essence, utilities were concluding that when there is a high level of QF offers, the avoided cost could be defined as the cost of purchasing additional power from the most competitively priced QF project. In 1984, the idea of issuing requests for QF proposals that could compete against each other emerged in the states of Maine and Massachusetts.



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While regulators and utilities were getting their act together, the demand for power was growing in several regions of the United States. Utilities were reluctant to build their own plants for several reasons. Utilities feared major cost overruns; the major failures they had experience in nuclear construction caused some of them to re-examine the assumption that bigger plants were better. They also did not like the high fuel prices and interest rates that were in effect at the time and their balance sheets were often not in a favorable position to take on the risk of new construction.

In this context, US utilities came to realize the advantages of QFs compared to conventional power plants:

- **First,** QFs are small compared to central utility stations. Therefore, QFs better fit the gradual increased demand faced by most US utilities. Being smaller, QFs are also easier to site and permit. In most states, permit reviews are simpler for projects below 100 MW, 75 MW or 50 MW. In addition, industrial cogeneration projects are generally built on existing sites where the incremental water, community, and socio-economic impacts are minimal.

- **Second,** being smaller and easier to site and permit, QF projects can be constructed faster than conventional plants with less chances of incurring cost overruns. A QF project generally can be built in less than 3 years under turnkey contract with price ceilings.

- **Third,** easier to site and less risky, QFs are accepted by financial institutions which are willing to provide project financing by extending highly-leveraged debt on a non-recourse basis. With this type of financing, financial institutions loan the necessary funds against the sole assets of the project, without having recourse to the equity owners of that project. For the lenders, the single most important asset in a QF project is its long-term power sale agreement because it is signed by a utility that is generally considered as a most credit-worthy institution. In the 1980s, QF projects were leveraged up to 85-95%, thus enabling them to produce power at lower costs and still generate higher returns than utility projects leveraged at less than 50-60%. In addition, cogeneration projects, with their higher energy efficiencies, are more cost-efficient than central power plants.

- **Finally,** utilities came to accept that there were knowledgeable, entrepreneurial and efficient non-utility organizations that could run their QFs as reliably as utility-plants. The was a growing recognition that increased competition in power generation led to more innovation in technology, more fuel diversity, and better diversification of risk.

As the need for new power kept growing, FERC proposed a ruling in early 1988 that would have standardized competitive bidding for QF plants. However, several states resisted saying that they wanted the flexibility to design their own QF selection processes and continue



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to use them as needed in case-by-case negotiations. Although it failed, the proposed ruling sent the message that competitive bidding was the way to go.

Currently, most US utilities issue requests for competitive bids for a certain amount of non-utility capacity that has to meet certain size, fuel and operation criteria and must come on line within a specified time window. Such bids can be either open or closed bids:

- In open bids, the request for proposal provides an explicit scoring system which is being used throughout the project selection and negotiation process.

- In closed bids, there is no scoring system, although the utility may provide some indications as to the types of projects it prefers.

In both cases, however, utilities are learning how to improve their bid selection process by evaluating QF offers not only on price but also on "quality". To judge the quality" of a QF offer may call for looking at up to 15 - 20 factors such as the use of certain local fuels; the impact on the local environment and economy; the type and reliability of the technology proposed; the timing of the project; its transmission fit; the quality of the planned operation and maintenance contract; and the reputation and track record of the sponsors behind each project. In some cases, the utility will bid its own plant or use as a benchmark a potential contract to purchase bulk power from a neighbor utility.

In this new competitive bid environment, QFs generally sell power at rates between 6 and 8 cents per kWh. At these rates, rates of return on QF projects can range between 15% and 25% depending on the degree of risk, location, and size of the project. To date, over 65 competitive bids have been issued by 48 utilities to request over 19,000 MW of non-utility generation capacity. The market response to these bids has been tremendous: over 1,950 projects were bid for a total in excess of 148,000 MW, that is almost 8 times what was being asked. These bids were issued by all types of utilities, including investor-owned utilities, public utilities and rural cooperatives.

### d) The Success of Non-Utility Generation in the US

The combination of increasing capacity needs, the utilities' reluctance to build new plants, and a growing acceptance of QFs by utilities, explains the emergence of a strong non-utility generation industry which has grown by 15% per year over the last ten years. The US QF market took off in 1985 and, since then, annual increases of 3,500 to 4,000 MW per year have been recorded. Year 1990 was a record year with over 6,000 MW of new operational capacity: this included 224 projects for a total investment in excess of $ 8.5 billion.

Overall, more than 30,000 MW of new QF capacity has been developed since 1980, representing over $ 40 billion in investments. QFs have provided about 15% of all the new



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power generation capacity installed in the United States since 1980. This proportion has subsequently increased from 25% in 1985 to 53% in 1990.

Today there are close to 3,000 non-utility generation projects in operation, representing a total generation capacity of more than 40,000 MW. This accounts for roughly 6 per cent of the total installed generation capacity in the United States. In 1990, QFs produced the equivalent of $9 billion in electricity sales. At this point, over 85 utilities purchase significant amounts of independent power.

QFs are very diverse in size and type of fuels. Gas-fired cogeneration, however, dominates with 45% of the total non-utility generation capacity in place. Next comes coal-fired cogeneration (15%). Small power projects account for 23% of the existing QF capacity, including projects with a broad slate of energy sources: biomass, waste fuels, hydroelectric power, municipal solid waste, and geothermal, wind and solar energies.

In addition, some 1,500 QF projects were identified as under development, representing potential capacity additions of nearly 70,000 MW, most of which will come on line between 1992 and 1995. This includes over 34,000 MW of gas-fired capacity, 11,200 MW of coal-fired capacity and some 6,000 MW of capacity that will use biomass or waste fuels; the balance (16,700 MW) will rely on renewable energy resources. Note that not all the projects forecasted will succeed; it is estimated that about 50% of all projects initiated eventually fail to be constructed due to their inability to meet various regulatory, permitting, or financial requirements.

In terms of applications, small power projects (most using renewable energy) account for the largest share of QF projects, both operating and under development. The next most intensive QF markets are cogeneration projects found in the chemicals, pulp and paper, and petroleum refining industries; these three industries combined host 18,000 MW of operational non-utility generation and could attract another 17,000 MW of additional QF capacity in the next five years.

Non-utility generation, with its flexibility and quick-on-line capability, will help US utilities meet their capacity needs across the entire country. Up to 200 competitive bids may be issued through 2000, requesting over 45,000 MW of non-utility generation capacity, first on the East Coast, but then spreading to the Southeast and Midwest of the United States, as the demand for new power generation shifts round the country. In most cases, utilities will solicit between 200 MW and 450 MW at a time.

In that context, it is projected that 54,700 MW of non-utility generation capacity will develop through 1999, including 26,200 MW of gas-fired capacity; 15,400 MW of coal-fired capacity industrial cogeneration; 6,500 MW of biomass- and waste fuel-fired capacity; and 6,500 MW of capacity relying on diverse types of renewable energy resources.



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Over 9,000 MW of non-utility generation capacity may therefore be in place by 2000. Through 1999, non-utility generation will provide about 46% of the total generation capacity that is expected to come on line. This bodes well for this new industry which is attracting more and more players. As the industry grows at 10% per year, some-non-utility companies will grow large in the 1990s. By 2000, leading players may control the equity of some 3,000 MW of non-utility project. By being involved in up to 40-50 projects in 20-30 states; the portfolios of this major players could then be worth $ 1 billion or more and their annual power sales are likely to exceed $ 1.5 billion.

### e) The New Energy Policy Act

A new national energy law, entitled the Energy Policy Act of 1992, which substantially expanded the scope of independent power in the US. This Act signals a new era by offering the following new terms:

- A new category of power plants, Electricity Wholesale Generators (EWG), are exempt from PUHCA and thus have similar status as Qualifying Facilities under PURPA, while they are still subject to the Federal Power Act and state regulatory commissions. There are no explicit fuel or size restrictions for EWGs and they have fewer restrictions on utility ownership.

- Transmission access will be broadened for wholesale power exchanges between utilities and independent power plants. This broader access to the grid will give independent power generators greater rights and opportunities to wheel power to utilities and major customers.

This new law is likely to result in a wide variety of new EWGs emerging on the market. EWG size will at first be limited by the realities of the power plant siting and the sizes of power capacity additions being required by utilities. Thus, most EWGs being developed in the United States over the next four years will likely still be below 400 MW, with 150 MW to 300 MW being quite popular. The competitive market conditions in the U.S. are also leading many developer to pursue major project overseas.

In addition, under the new Act, FERC can order wheeling between utilities, or between QFs or EWGs and utilities, or between QFs or EWGs and major industrial customers as long as the transaction meets four conditions: (1) it involves wholesale power only; (2) it is in the public interest, (3) it does not jeopardize the reliability of the grid, and (4) it involves wholesale power that is transacted at a "just and reasonable" price.

With this new Energy Policy Act, the independent power market in the US is opening a new chapter that will lead to a wider variety of opportunities for independent power generators.



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### f) Lessons Learned from the US Independent Power Experience

In conclusion, we can say that PURPA has had a positive effect on energy efficiency since cogeneration has inherently higher thermal efficiencies than power-only technologies. In some cases, utilities were forced to purchase relatively expensive power typically from renewable energy power plants; the responsibility for this situation being largely due to poor decisions made by the utilities themselves. PURPA, however, had a good impact on diversity of technology and fuel supply and it has reduced the probability of a single large outage. The impact has also been positive on reducing oil dependence, although the use of indigenous gas has increased. More importantly, however, PURPA has brought on power that was badly needed in some key states and has reduced the capital requirements of several utilities that were not willing to build or were not in a good financial situation to do so. Other points have been learned in the last ten years:

- Non-utility plants can be integrated into a utility system with a reasonable set of interconnection and dispatchability requirements, although dispatchability can remain a problem in some cases.

- Once on line, non-utility plants can be quite reliable.

- Utilities are getting better at calibrating proposals from non-utility generation companies through better negotiations, more thorough due diligence, and by using monetary incentives such as imposing fees for entering the bidding process and imposing penalties for failure to meet operating requirements.

- It is useful to develop clearly defined requests for non-utility power to allow a good negotiation climate.

- It is preferable to adopt standardized power purchase contracts to facilitate negotiations and project financing.

- Utilities need to balance price and quality factors to arrive at the right avoided cost and reflect possible changes in future capacity conditions.

Overall, the non-utility generation experience in the United States is a unique experience of unmatched magnitude in the world. Yet it did not emerge as the result of a drastic and definite intent to deregulate the US power generation sector, but rather as a long-term simmering spin-off of a law aimed at promoting energy conservation in a marginal way. PURPA, however, did succeed in making the US electric industry more competitive, although this process has been long and tortuous in the minds of several non-utility companies.

Looking back over the US experience, one can conclude that to be successful, an independent power promotion program has to meet three conditions:



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- It must be clear in its objectives: what level of diversification or privatization is sought? What type of projects are being preferred? Where should these projects be built and when would be the best time to build them? How can power pricing and Integrated Resource Planning be best implemented to meet both economic and social objectives?

- It must foster a climate of trust between the utilities and the private power developers so that projects do proceed on a timely basis and that precedents can be taken for granted. In addition, the sharing of risks must be defined: for example, who is taking the risk for fuel price changes, environmental permit failures or over building capacity?

- It must be accompanied with the right incentives for utilities to participate fully and help contribute to the objectives set forth by the private power program.

These lessons from the US context have played an integral part in the evaluation of Bulgaria's policy and legal framework, as reviewed in Chapters III, IV, and V.

### 3) Relevant Case Studies of Independent Power Programs in Transitional and Emerging Economies

Three countries have been selected to profile the development of the independent power policy and institutional framework and the commercial market: Poland, Argentina, and Spain. The experience from these countries in combination with the US experience will provide valuable lessons for developing independent power in Bulgaria.

#### a) Poland

The power system of Poland had a total capacity of 31,390 MW in 1989, composed of some 400 power plants and generating over 125 billion kWh. Eighty-five percent of total power generation comes from coal-fired power plants. The power sector is comprised of 28 power generation companies, 33 electricity distribution enterprises, 4 lignite mining companies, and a wide variety of equipment manufacturers, maintenance organizations, and engineering firms. It is estimated that about 5,100 MW of capacity will be needed by the year 2000 and an additional 8,000 MW to 12,000 MW by the year 2010, with much of this capacity being in the form of rehabilitation and repowering of existing power plants.

Until 1990, the entire power sector in Poland was state-owned, with the exception of a few small hydro power stations. After beginning the transformation of the Polish political and economic system in 1989, it was decided to privatize the state-owned power companies. In 1990, the Parliament liquidated the Power and Lignite Board and began the process of converting all the power companies into independent joint-stock companies. In addition, a new joint-stock company, PSE-SA, was formed to own and operate the high voltage transmission system and the pumped storage power stations. PSE-SA also dispatches the



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power stations, prepares load forecasts, and purchases power from the generating companies. The Polish Government will initially own 100% of all the joint-stock companies. It plans to sell off most of the generation companies, but will always maintain a 51% shareholding in PSE-SA.

The regulation of the power sector is expected to be conducted both at the local and central government levels. The activities of the distribution companies are to be under the jurisdiction of local provincial governments, while the PSE-SA will be under central government control. A national regulatory body is to be established to license generation and distribution companies and set wholesale power rates. The legislation implementing this scheme is still under consideration by the Parliament. More recently, the Polish Government has established new policies for energy pricing in order to improve the efficiency of energy supply and use and to mobilize additional capital for investment.

Substantial efforts are underway to eliminate subsidies in the energy sector. The P Government has already reduced the subsidies paid to coal miners and transporters. Simil the wholesale prices paid to producers of power and heat are being increased. The first en pricing study has been completed in order to estimate the long-term tariffs. Ultimately, bulk power prices may be regulated by competitive bidding, even on an hourly basis. There is a major commitment to increase retail electricity and heat rates and to eliminate cross subsidies.

With these reforms underway, the Polish Government has begun implementing a program to encourage private investment in the power sector. Several generating companies have already been transformed into joint-stock companies and are now negotiating with foreign companies that propose to form joint ventures with the joint-stock power companies and invest in the rehabilitation of power plants. The joint-stock companies will contribute the value of their plants and the foreign investors will raise new capital on a project finance basis.

In order to finance independent power projects, it is essential that these joint ventures secure long-term revenue from the sale of power (and steam, if any). Therefore, with the assistance of USAID, PSE-SA has developed a model power purchase agreement to govern its purchase of power from the joint ventures. Several power purchase contracts are in the process of being negotiated with different joint ventures. US AID consultants are also representing district heating companies in their negotiations with the joint ventures and advising various ministries of the Government with respect to government guarantees being requested by foreign investors.

The major issues that have arisen in Poland are the same issues that are likely to arise elsewhere in Eastern Europe. The valuation of the joint stock company's existing assets has proven to be a very difficult problem because the public treasury desires a high valuation and the foreign inv rs fear a high valuation will undermine the bankability of the projects. As a result, indepe nt experts are usually asked to conduct this valuation.



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The uncertainty of the future pricing arrangements throughout the power sector has complicated the process. PSE-SA, for example, does not want to agree to a wholesale power purchase price which is higher than that it can collect from the sale of power to the distribution companies. For their part, the joint ventures do not want to invest time and money in the negotiation of "non-price" terms in the power purchase agreement until the purchase price of power is known.

Similarly, the on-going restructuring of the power sector and the possibility of further changes in the regulatory environment have also created difficulties. The Polish Government naturally seeks to avoid undertaking obligations in the various agreements that may be inconsistent with the subsequently imposed rules, and the joint ventures cannot assess the risks which they confront. For example, there is a concern that more stringent environmental laws may be enacted in the near future. Because compliance with these laws could be costly, the joint ventures have asked for protection against such increased costs. The Polish Government, however, does not know if these laws will be applied retroactively, and, if they are, it is unclear which governmental agency should offer protection. Such problems can be minimized if restructuring is completed and a stable regulatory environment is established early.

Assuming these problems are overcome, there will remain a question concerning the availability of Government guarantees. Because the bankability of independent power projects depend on the revenue stream from one or more Government-owned entities, the joint ventures have closely examined the creditworthiness of these entities. To ensure that they receive payment, the joint ventures have requested that the Government guarantee the obligations of the Government-owned companies. Unfortunately, the Government has limited capacity to guarantee obligations, and it must allocate this limited capacity among many different public purposes. This issue is still unresolved in Poland.

As is evident, the independent power policy and institutional framework in Poland is still in the early stages of development. A variety of independent power developers and equipment vendors from the US and Europe have been negotiating joint ventures with the joint stock companies to develop specific projects. While various joint-ventures and power purchase agreements are in various stages of completion, no independent power project in Poland has been successfully financed to date.

**b) Argentina**

The Secretariat of Energy regulates the power sector and has owned the major utilities. The Secretariat of Energy (SE) is under the jurisdiction of the Ministry of Economy and Public Works and Services. SE regulates electricity supply throughout most of the country and grants and controls electric concessions through the National Directorates for Coordination and Regulation of Prices and Rates for Electricity Planning. The Federal Board of Electric Energy is an advisory body for SE and is made up of representatives from each of the provinces. Under SE, the Ente Nacional Regulador de la Electricidad (ENRE) is responsible for



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establishing the basis for tariff calculations, defining the terms for awarding concessions, and safeguarding public safety, environmental protection, and property rights. The government-owned electric utilities that have operated under the jurisdiction of SE are: Agua y Energia Electrica (AyE) (4,818 MW of both thermal and hydro); Servicios Electricos del Gran Buenos Aires (SEGBA) (2,703 MW entirely thermal); and Hidroelectrica Norpatagonica (HIDRONOR) (2,770 MW entirely hydro). The government is in the process of privatizing the generating assets owned by all three of the above utilities.

The President's Office manages the nuclear capacity while provincial utilities are managed by local governments. The National Atomic Energy Commission (CNEA) oversees the construction and operation of Argentina's 1,018 MW of nuclear capacity involving two power plants located in the Central and Lotral regions of the country. Provincial governments own and operate the provincial companies and cooperatives, which represent a total of 729 MW of capacity. The national grid is extensively interconnected. The national electricity grid Sistema Interconectado Nacional (SIN) is based on a network of 500 kV and 200 kV lines that interconnects 90% of the entire power systems (1990), with only the provinces in the far east and the south being separate.

The demand for electricity increased by an average of 4.0%/yr over the period of 1970 and 1990, reaching about 40,481 GWh in 1990. Between 1992 and 2000, electricity demand is expected to grow between 4% and 8% per year, depending on economic growth. Total installed capacity is expected to increase from 11,865 MW to 17,421 MW between 1992 and 2000. Some new nuclear capacity and little new thermal capacity is planned. Major improvements in the poor capacity factor for some thermal power plants is expected. The vast majority of the increased capacity will come from three new hydro complexes. This capacity expansion is expected to call for between $6.8 and $10.2 billion dollars of new investment, not even taking into account the privatization investments in existing capacity.

Argentina has come out of a period of hyperinflation that exceeded 5,000%/yr and negative GDP growth of -4.0%/yr or less during the late 1980s; a failed war with Britain over the Falkland Islands; and a transition from military to democratic government. President Carlos Menem and his economy minister, Domingo Cavallo, dramatically revamped and stabilized the economy by 1991 through an ambitious economic restructuring involving anti-inflationary monetary policies; deregulation of commerce and financial markets; successive agreements with the IMF; opening of domestic markets to international competition; and extensive privatization of government-owned corporations.

Argentina's privatization program has completed the sale of the telecommunications (ENTel), airline (Aerolineas), and steel (SOMISA & Altos Hornos) corporations as well as various chemical, television, shipyards, subway, financial, and railway companies. In the energy sector various oil and gas companies and electric power and transmission facilities have been privatized. The decision to privatize most of the government-owned companies is designed to attract badly-needed private capital, reduce the government's public debt, encourage competition, and promote economic and technical efficiency.



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The process of demonopolizing the power sector was initiated by the Menem regime, which came to power in 1989. This program is based on various pieces of key legislation: Executive Decree #634, the Proyecto de Ley #15336, the Resolution 38/91, and the new Resolution 61/92. The objective of these laws and regulations are to transfer ownership of government-owned utilities and power projects to the private sector, encourage competition where possible, adjust power prices to reflect actual cost of generation, and protect consumers by regulating the tariffs, power quality, and rate of return earned by power companies.

The pace of privatization has been dramatic. As of the end of 1992, 3,115 MW or about 26% of the installed capacity in 1992 largely owned by the government had been privatized. The government is aggressively pushing its power sector privatization program and would like to complete the entire power sector privatization program before the end of 1993. While this timetable is likely to slip somewhat, the pace is nonetheless dramatic.

The competitive pricing of power is administered by the new entity, CAMME. The Argentine government set up the Compania Administradora del Mercado Mayorista Electrico (CAMME) as an operational company in August, 1992 to perform a range of power plant dispatching and electric tariff coordinating functions for the Wholesale Electric Market (WEM). While ENRE of the Secretariat of Energy performs the tariff regulatory functions, CAMME is charged with the actual implementation of rate setting. Its key responsibilities include determining the spot market prices based on market and regulatory guidelines, supervising and monitoring the electric system, programming the supply of electricity on a daily, weekly, seasonal, and mid term basis, controlling the system of power plant dispatching, distributing the payments between generation and transmission companies, and administering contracts. The Board of Directors of CAMME is composed of representatives from government, generators, transmitters, and major customers, thereby giving most of the key players in the power sector a role in decision-making.

Power pricing is based on separate spot and bulk contract markets. There are two parallel markets for power, the spot and bulk contract market. Large industrial customers have begun to enter into long-term contracts with specific generation companies. The remaining power is supplied on the spot market, where prices are determined by the mean fuel cost of the most expensive unit in operation and the cost and probability of a loss of load at any given time. The economic dispatch priority will tend to favor hydro generation first (when available), then nuclear, and finally fossil generation. In the first few years since its inception in 1992, the spot market will account for a major volume of power flowing between generator and consumer. It is expected, however, that the system will eventually mature to consist mostly of long-term power contracts and that the spot market will be limited to the purchase and sale of contingency service and surplus power, as is developing in the newly privatized power system in the United Kingdom.

Five power projects have been privatized to date. As of the end 1992, seven major power projects have privatized: Puerto (1,009 MW gas and fuel oil), Costanera (1,260 MW gas and fuel oil), Alto Valle (97 MW, gas), Guemes (245 MW, gas), Pedro de Mendoza (67 MW,



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gas and diesel oil), Dock Sud (2 MW, gas and diesel oil), and Sorrento (226 MW, gas and fuel oil). All of these project ha een thermal plants located in the greater Buenos Aires, Neuquen, Salta, and Sante Fe re ns. A total of 3,115 MW or about 26% of the total 11,865 MW installed in 1992 have been p vatized. Foreign developers from Europe and the US have made major power investments. Power project bids often required assuming repair and debt liabilities as well as allowing for a small share of employee ownership. The percent of the project sold never exceeded 90%, since 10% was always reserved for the employees. In some cases such as with Puerto, Costanera, and Guemes, the government retained 20% for possible later sale. In addition to the cash investment, developers also sometimes agreed to make investments in repair and assume certain amounts of outstanding debt.

Selection of winning bids has been based on price and qualifications. While the particular terms for each power project sale is confidential, it would be fair to say that the most important criteria for the selection of winning bidders was (a) the technical and managerial capabilities of the bidder to operate the project (so as to qualify for a short list of bidders) and (b) the price offered. In setting the offering price, bidders would naturally have examined the age, efficiency, reliability, and other performance characteristics of each unit as well as the personnel requirements, fuel costs, generation cost, dispatch potential, potential sales price, etc. Interestingly, the bidders came up with a wide range of offering prices. Bids for Puerto ranged from between US $43 and $92 million, for Alto Valle ranged between US $12 and $22 million, for Guemes ranged between US $53 and $87 million. In all cases the highest bid won. These wide spreads in the offering price indicate there were major differences in the bidders' estimated value for these projects.

There are no major constraints to accessing financing. Many investors have quickly responded to the favorable business climate in Argentina. In 1992 alone, over US$ 1.4 billion of direct investment in Argentina's electricity generating and transmission/distribution assets have been made by broad range of international and domestic investor and lender groups. The political and financial risks in Argentina have declined markedly since the unstable periods of the 1980s. Foreign commercial and investment banks such as the Bank of Boston, Citibank, J.P. Morgan, Chase Manhattan, First Boston Group, Paribas, ING, etc. are all players in this rapidly developing power project privatization market. Nonetheless, there is a note of caution. Obtaining long-term debt financing will probably require credit support from government agencies or multilateral development banks. While capital is quickly returning to Argentina, only three to five year terms are currently available; it may be several more years before long-term debt becomes available. Local financial markets are not particularly familiar with non-recourse project financing terms, so presently most investment capital is coming from outside the country.

### c) Spain

The power sector in Spain is centrally regulated by the Ministerio de Industria y Energia (MIE). In 1985, the government nationalized the main high-voltage grid, creating Red

Electrica (REDESA) which is 51% controlled by the government. As owner of the main grid, REDESA and the government control the central dispatching system, determining which plants will generate power and when. In theory, dispatching is based on cost of generation and availability criteria, while in practice preference is given to domestic coal fired-plants. All the electric utilities in Spain (both government and privately owned) are members of a central utility industry organization, called the Unidad Electrica, SA (UNESA). While power planning is initiated by each individual utility, considerable coordination is managed by MIE and UNESA. MIE determines the uniform electricity price throughout the country based on a standard cost recovery methodology, regulating revenue transfers between utilities to make up for differences in the cost of generation.

Spain had a total installed capacity in 1990 of 43,490 MW, with 16,103 MW of hydro, 7,363 MW of nuclear, 9,362 MW of domestic coal, 1,314 MW of imported coal, 6, 574 MW of oil, 1,320 MW of gas, and 1,454 MW of self-generation. The Spanish power sector was originally composed of a relatively dispersed group of some 21 largely privately-owned companies that generated and distributed power in respective territories. Since 1985, a consolidation began with a government-sponsored asset swap, where some of the financially strong utilities acquired assets in the weaker companies. In the past two years, this consolidation has accelerated when most independent utilities were subsumed by Empresa Nacional de Electricidad (ENDESA) or the Iberdrola group through mergers, takeovers, and share acquisitions. The 100% government-owned Instituto Nacional de Industria (INI) owns 75% of ENDESA (with the remainder being publicly traded). Proposals that the government sell off more of its share in ENDESA to reduce the national debt are unlikely to take place and certainly would not lead to the government reducing its ownership share below 51%. Iberdrola, on the other hand, is an investor-owned consortium (involving the merger of Iberduero and Hidroelectrica Espanola). Two smaller independent power companies also remain, Union Fenosa (UEFSA) and Hidroelectrica del Cantabrico. In terms of 1991 installed capacity, ENDESA has 43.8%, Iberdrola has 36.4%, UEFSA has 11.9%, and Hid. del Cantabrico has 3.4%.

The primary motivation for the above-mentioned consolidation has been to make the Spanish power sector more financially viable and competitive in the unified European market. With the EEC's new policies regarding Third Party Access (TPA) and a general opening of the power markets to greater competition, the Spanish power sector recognizes that it needs to consolidate into larger companies to compete against the large mostly government-owned utilities on the continent.

Between 1991 and 2000, the National Energy Plan calls for the addition of 8,377 MW. Total installed capacity in 1990 was 43,490 MW and the expected installed capacity in 2000 will be 51,450 MW. This expansion plan assumes an annual growth in power demand (adjusted for the energy program) of 4.03% between 1990 and 2000, with the major increase being in the transport, residential, and commercial sectors. This growth in demand and capacity expansion is regarded by some to be optimistic, given the slowdown that has been taking place in the Spanish economy (real GDP growth has declined from 5.2%/yr in 1988 to an estimated



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1.7%/yr in 1992). This expansion plan expects there to be a substantial increase in the relative share played by gas-fired and self generation and a decline the relative role for nuclear and oil.

National policy on the development of private power has only focused on promoting hydroelectric power and industrial cogeneration. The government has not encouraged or even permitted private development of independent thermal power plants. Between 1982 and 1988 various laws and regulations have been passed that actively promote industrial cogeneration. A national law has been established that gives cogenerators the right to sell power back to the grid if the cogeneration facility exceeds a combined electricity and thermal heat rate of 5700 kJ/kWh or an efficiency of about 63%. The law establishes a simple equation for calculating the buy-back rate at between 85% and 95% of the industrial rate, depending on whether firm capacity is guaranteed or not.

About 2,450 MW of industrial cogeneration expansion is anticipated between 1990 and 2000. The rapid expansion of cogeneration is due to: (a) an ambitious new policy to promote industrial cogeneration, (b) high industrial tariffs , and (c) limited installed cogeneration capacity to date in Spain (i.e. only about 3% of total electricity production versus about 15% in most industrialized countries).

Prior to 1986, only 750 MW of cogeneration capacity was installed in Spain. Very few of these projects are selling electricity back to the grid. Between 1986 and 1992, there have been 85 new industrial cogeneration projects with a total capacity of 871 MW installed, more than doubling the capacity in as little as six years. Seventy five percent of these projects have a capacity of less than 10 MW while only 3 projects or 4% of all projects have a capacity in the range of 50 to 80 MW. A substantial number of these new projects have involved incremental sales of electricity to the grid. Of the 871 MW installed between 1986 and 1992, 54 projects or 63.5% of all projects involve simple gas turbines with 16.5% involving combined cycle systems, and 13% steam turbines. This trend is a reflection of the overall trend in Europe and Spain towards using gas to reduce environmental emissions and to capitalize on the low costs and high efficiencies of new combustion technology.

Unlike its neighbor, Portugal, where large scale BOT power projects have been tendered, the Spanish government and electric utilities have traditionally been opposed to opening the market to major independent power projects. With the government owning a majority of the power sector and there being entrenched political and economic interests, the general assumption has been that the IPP market is unlikely to develop any time soon. A recent announcement, however, by the Secretary of Energy, Ramon Perez Simarro, has shed more light on the Ministry of Industry and Energy's (MIE) plan to submit an ambitious new law to the parliament that would call for an opening of the power sector to bulk independent power generation. Secretary Perez Simarro proposes in the new electric power law to maintain the existing central power planning system, to separate generation from transmission and distribution (T&D) in a way that maintains the government monopoly control over the main transmission and dispatching network, and introduce greater competition in the



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generation sector by allowing independent bulk power generators to undercut the electricity tariffs established by the MIE. If independent producers can profitably sell power at prices lower than the established tariff, the Secretary Ramon Perez would like to give them the right to access the grid.

The European Commissions proposal for Third Party Access (TPA) is a key component of the European government's plan to open the market to competition. Strong opposition to the European Commission's TPA proposal has been mounted by the continental members of Eurelectric (the European electric power industry association). The major case against TPA forcefully argued by Eurelectric is that free competition will threaten the reliable supply of power, could lead to greater volatility in electricity prices, would require a wide array of burdensome new regulations, and could possibly compromise efforts to reduce the environmental impact of power generation. While it is acknowledged that competitive power markets could lead to lower prices in the near-term for large (e.g. industrial) customers, opponents charge that a free power market would raise electricity prices for small (e.g. residential) customers (as has occurred in the United Kingdom). Opponents try to cast the independent power experience in the United States and the United Kingdom in a negative light, citing these markets as not being examples worth emulating.

The free market proposal in this pending new Spanish electricity legislation will need to pass parliament and could face stiff opposition. In the Spanish market, the government-owned ENDESA and other elements of the government are opposed to opening the market to bulk independent power generation. On the other hand, the privately-owned Iberdrola supports an opening of the market; they see free competition as in their best interest since the current rate-setting and dispatching system is regarded as favoring ENDESA. The submission of the new electricity law has been delayed for many months, it is unclear whether the law will be submitted and voted on before the general election the government must call before October, 1993. Even if the law is largely accepted, it is unlikely that the market will result in the open competition found in the United Kingdom or lead to truly competitive large tenders.

The Spanish economy, the eighth largest of the industrialized countries, experienced real GDP growth of 5.2%, 4.8%, 3.6%, and 2.4% from 1988 to 1991, respectively. This growth was approximately 1% higher than the average economic growth in the European Community. In 1992 the estimated growth rate is lower, but still a positive 1.7%. Moderating growth in 1992 and in the future reflects weaker international conditions as well as specific Spanish monetary policies. There are no appreciable shortages or barriers to raising capital for projects with an attractive return on investment, due to a favorable investment climate and continued strong economic growth (GDP growth: estimated at 1.7%/yr for 1992). While short-term prime lending rates were in the 16% range in 1990 (due to efforts to restrain an economy and credit supply that has been expanding too rapidly) these rates have been declining to reaching 13.8 in 1992.



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Given the high electricity prices in Spain (e.g. 1989 industrial rate for 10 MW, 50 GWh/yr load is 8.7 Pesetas/kWh or ~ 9.3 cents/kWh), returns on investment in cogeneration projects are very attractive. The government cogeneration development company, IDAE, has estimated internal rates of return between 20% and 65% for cogeneration projects and has been aggressively developing projects to capitalize on these attractive opportunities. The major utility groups, ENDESA and Iberdrola, are both expanding into the cogeneration business as well.

### 4) Structure and Sources of Independent Power Financing

Privately financed IPPs typically are structured as separate project companies that raise their capital on a non-recourse project financing basis. This method serves to mobilize private capital more effectively by limiting the liabilities of the project owners. In the event of default or bankruptcy, the lenders or investors have little or no right to the assets of the owners of the company; the only collateral they have is in the assets of the specific project company. For this reason, the financing of independent power involves carefully defining and structuring a project so as to properly manage and minimize its risk of failure. With an effectively defined and structured power project, it is possible to attract the investors that would be willing to accept the risk and reward profile of their particular investment.

#### a) Independent Power Ownership and Financial Structures

The structure of a non-recourse financed independent power project is shown in Figure 2. According to this widely-applied model, a developer would establish a project company in Bulgaria dedicated to the financing, construction or repowering, and operation of a specific power project. The sources of financing would be from senior and subordinated debt and from equity in the form of preferred and common stock (as discussed below). In the international market, various types of loan guarantees and risk insurance are often required by lenders and investors.

As shown in Figure 2, this project company would enter into a clearly-defined power purchase contract with NEK that spells out NEK's power purchase rate over a period of approximately 20 to 25 years. Power purchase rate, fuel price, inflation adjustments, terms for penalties or bonuses, etc. would be specific elements of this contract. Given NEK's limited creditworthiness at the present time, it is highly likely the developer would seek specific Bulgarian government guarantees of NEK's financial commitments to pay under this power purchase agreement. The power purchase contract and guarantees are part of a carefully structured security package (with the government, lenders, fuel suppliers, plant operators, contractors, etc), as shown in Figure 3. The developer would need to obtain these agreements to reduce and distribute the project's risk so that financing can be obtained. [See Chapter V, Recommendation 6]



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# Private Power Project Financing

For a Build, Operate and Transfer (BOT) Power Project

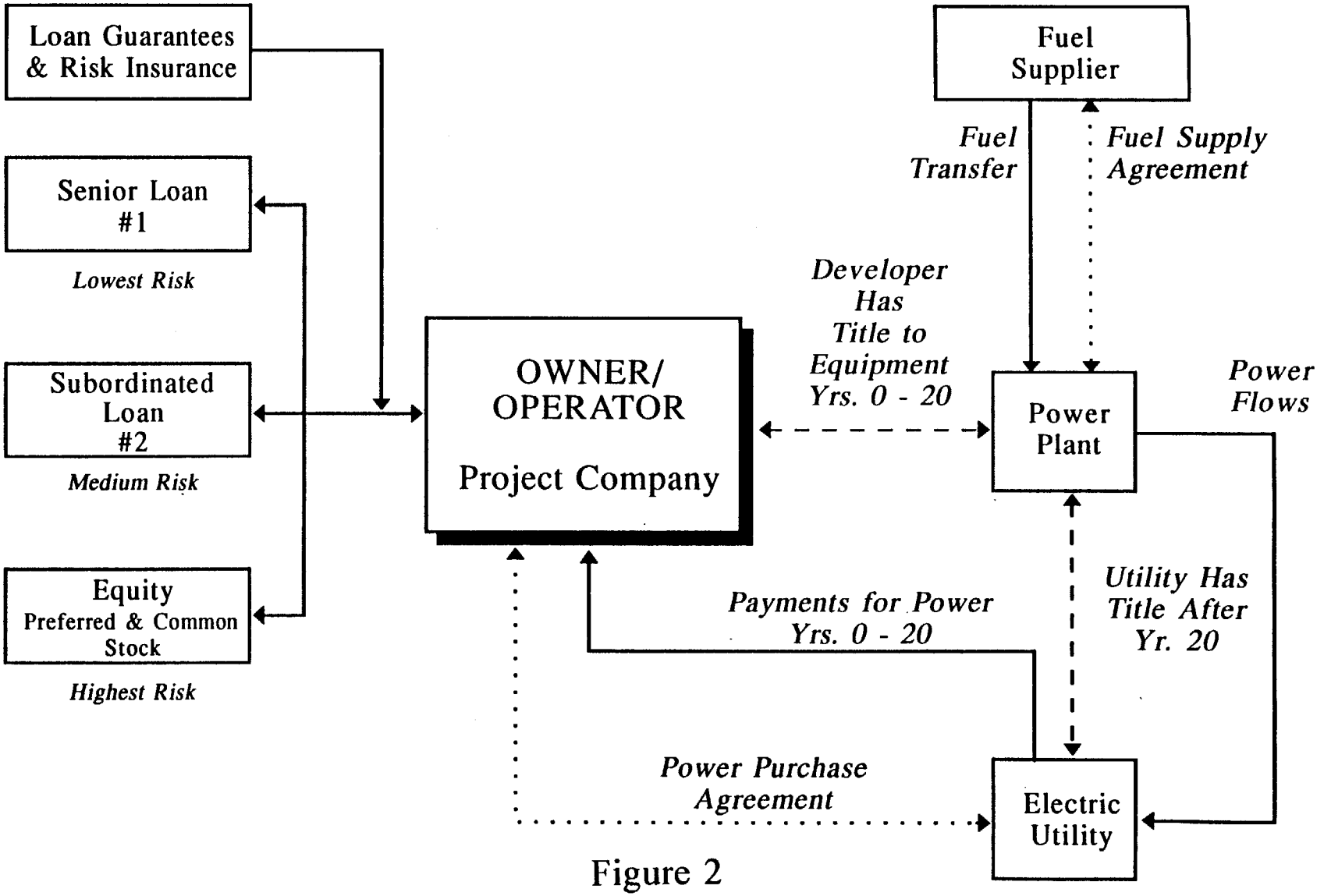


Figure 2

# Security Package for a Private Power Project

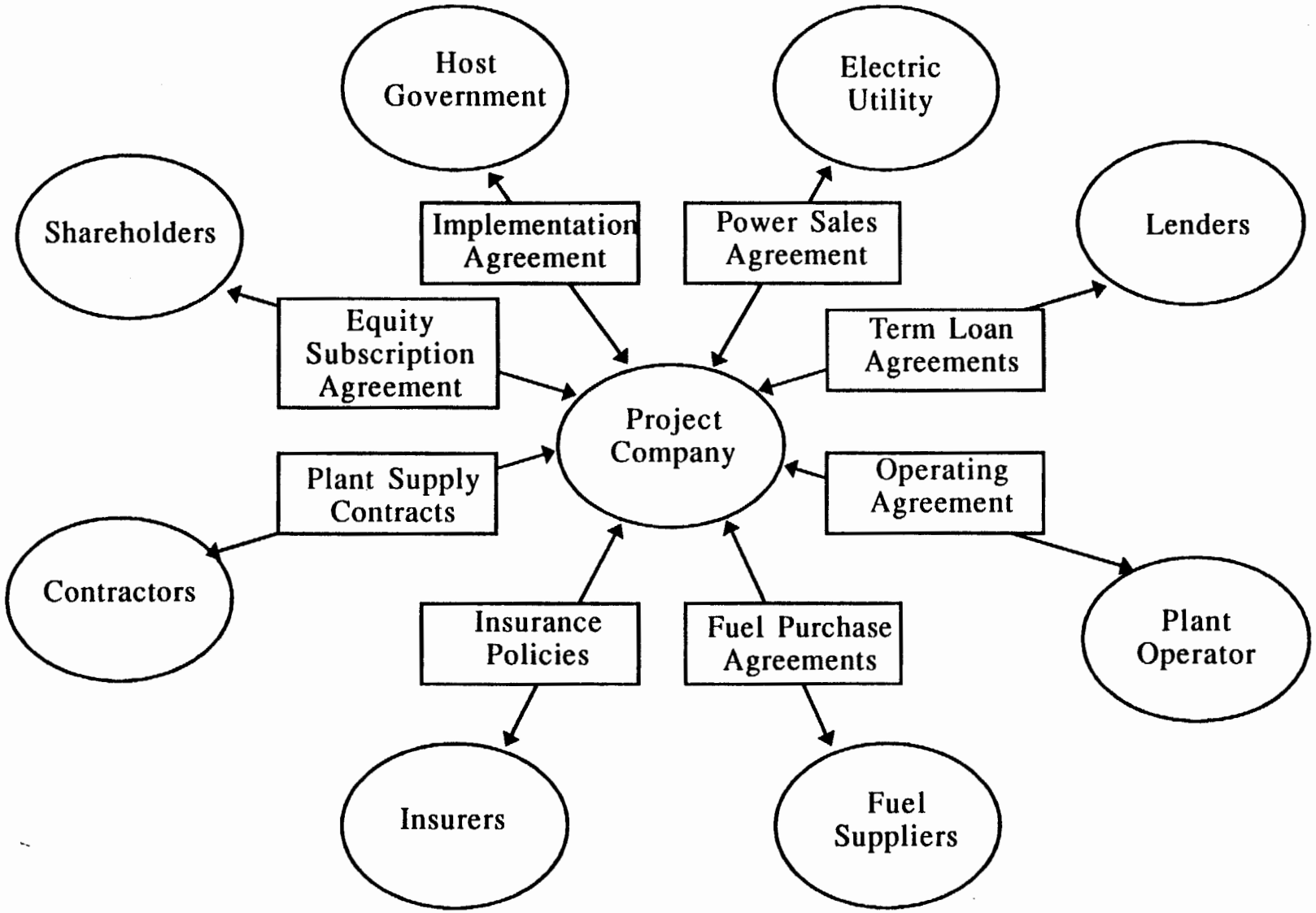


Figure 3

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The long-term ownership structure of international independent power projects has been based on different models commonly called BOO, BOT, and BLT.

* **Build, Own, and Operate (BOO)**: The private developer finances, builds, owns, and operates the project for the entire serviceable life of the power plant without ever transferring ownership to the utility.

* **Build, Own, Operate, and Transfer (BOOT or BOT)**: The private developer finances, builds, owns, and operates the power project for a prescribed term of about 20 years. After this period in which the debt has been serviced and the equity investors have earned their return, the ownership of the project is transferred from the private developer to the electric utility.

* **Build, Lease, and Transfer (BLT)**: The project developer finances and builds the project and then leases it to the utility in exchange for an agreed upon rent or lease payment. Leasing is particularly favored in those countries which have constitutional restrictions on private ownership of a power plant.

The most common models being applied to independent power projects in emerging and transitional economies is the BOO and BOT framework.

### b) Sources of Financing

With thorough analysis of a good power project and a favorable power purchase contract and other agreements in hand, the developer should be able to raise capital necessary to finance the project. The two sources of capital for financing any project are equity and debt capital:

* **Equity Capital**: Internationally, equity investors typically supply about 20% to 30% of the project investment requirements. The equity investor takes on a major portion of the project's risk because his return on investment over the life of the project is a function of the project's financial performance.

* **Debt Capital**: Debt capital is supplied by a bank through a loan or from the sale of bonds and typically supplies about 70% to 80% of the project's capital requirements. The debt investors take less risk because they have first rights to any liquidated collateral in the event of project failure. For their lower risk exposure, debt investors are offered only a lower fixed return over a typical 10 to 20 year term.

The scrutiny a proposed power project receives in raising the equity and debt financing is the most critical phase in the development of an IPP. There typically are two stages of financing a power project: construction and operation. Construction financing covers the one to four years typically required to complete the construction of a conventional thermal or

hydro power plant. During this phase the project is not earning a return, since it is not selling any power. A turn-key construction contractor is typically required to take on the construction risk and commit to completing the project on a fixed price basis. Once the power project has been commissioned, the operation phase of the project is financed over a period of 10 to 20 years. At this stage, the owner and operator of the project assume the operation risk and are earning the revenues needed to service the debt and pay a return to the equity investors.

One of the major hurdles of successfully financing an independent power project is satisfying the requirements of the lenders. The ratio of debt to equity varies based on the risk in a particular market. During the highly favorable US independent power market conditions of the 1980s, some projects were financed with 100% debt. Today in the US market, at least 10% equity is required, with 20% being common. In the riskier markets of the developing and transitional economies, equity requirements of 20% to 30% can be expected. In these riskier markets, developers will require higher returns on equity than is currently earned in the US. Given that lenders are supplying between 70% to 80% of the financing, they will subject any project to very close scrutiny before agreeing to lend.

Given the size and complexity of many independent power projects, financing often involves the syndication of debt from multiple sources. For sizeable power projects, it is not uncommon for various multilateral, bilateral, and commercial financial institutions to syndicate their debt financing into a carefully structured package. While these arrangements serve to diversify the risk across multiple institutions and leverage each bank's limited resources, the process of structuring the financing can be significantly delayed. As it is often said, "time is money." If the process of negotiating a project and raising financing is unduly burdensome, the ability to successfully implement projects will be constrained. Many of the policy and institutional recommendations raised in Chapter V of this report will facilitate independent power by reducing real and perceived risks and procedural delays in raising financing.

The main question is what sources of capital would be interested in investing in a Bulgarian IPP. Two major risk factors are typically considered: country risk and project risk. Country risk typically involves such political risks as war, insurrection, expropriation of assets, inconvertibility of currency, and exchange rate volatility. Project risk typically involves construction cost overruns or delays, poor power plant performance, non-compliance with power purchase or fuel supply contract, etc. With the necessary legal contracts, project risk is usually considered manageable by a developer. Country risk, on the other hand, represents a danger of failure that the investor has much greater difficulty controlling. Country risk ranking services such as Euromoney and Institutional Investor grade most of the countries worldwide according to a range of economic and financial indicators. For instance, Euromoney uses 9 criteria that include economic data, political risk indicators, debt indicators, access to bank finance, access to short-term finance, access to international bond and syndicated loan markets, access to and discount on forfeiting, credit ratings, and debt in default. For instance, Bulgaria had a listing of 118 out of 169 countries in the March 1993



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edition of Euromoney. This rating reinforces the earlier conclusion that Bulgaria's credit risk would be regarded as unacceptable for most commercial banks at this time.

In emerging and transitional economies, the primary source of debt and some equity capital is from the multilateral and bilateral institutions. Commercial banks are often very hesitant to take on the risk in these markets without a major involvement of the multilateral and bilateral institutions. The International Finance Corporation (IFC) (which is part of the World Bank Group) and the European Bank for Reconstruction and Development (EBRD) are two key contenders for providing debt financing for independent power projects in Bulgaria. Bilateral institutions such as the Export Import Banks of such countries as the US and Japan have been involved in financing independent power projects. Political risk insurance (against expropriation, insurrection, and inconvertibility) and loan guarantees are typically sought from bilateral agencies, such as the US Overseas Private Investment Corporation (OPIC) and the US Export-Import Bank (EX-IM). Foreign and domestic commercial banks are likely to play only a small role in the early independent power projects in Bulgaria, particularly with current Bulgarian interest rates (greater than 60%) and short terms (less than one year).

To illustrate how independent power projects are financed, it would be worth providing an example. Given the rapidly growing demand for power and the major financial constraints, Asia in general and the Philippines in particular has been the site for some of the first major IPPs. A newly-financed project of particular note is the 700 MW coal-fired Pagbilao power project in the Quezon Province of the Philippines. This project is jointly being developed by Hopewell Holdings of Hong Kong (an infrastructure project developer), Mitsubishi Corp of Japan (a power equipment vendor), and Black & Veatch International of the US (an engineering construction company). This project is being built under a 25 year Build, Operate, and Transfer (BOT) agreement with the Philippine National Power Corporation (NPC). The NPC agrees to buy power from the developer under a take-or-pay power purchase agreement, with NPC also supplying all the fuel (coal) for the project.

The financing of the Pagbilao power project is of particular interest. The total project cost is $888 million, with about 75% being financed from debt sources and 25% equity. $535 million of the debt financing is being jointly supplied by the Export Import Banks of the US and Japan. This project could be a trend setter in that it is the first time the US and Japanese export credit agencies have jointly-financed a major project. The remaining debt is being furnished by the International Finance Corporation (IFC), the Asian Development Bank (ADB), and the Commonwealth Development Corporation (CDC). The project developer, Hopewell is supplying $200 million or 77% of the equity financing, with the IFC, ADB, and CDC also providing some equity.

As will be the case in Bulgaria, multilateral and bilateral sources of financing played an important role in the Pagbilao power project development. While developers and equipment suppliers are willing to put their capital at risk, commercial banks will likely be slow



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to participate in the early stages of an independent power market in emerging or transitional economies.

## 5) Independent Power Lessons Applicable to Bulgaria

### a) Benefits of Independent Power

The policy motivation behind promoting independent power in different countries can vary significantly. In developed countries, the objective has typically been to promote competition, efficiency, and the integration of a more diverse array of generation technologies and fuels. In developing and transitional economies, the goal has included the above objectives but has been primarily to attract private capital into a financially constrained power sector. The benefits of independent power to Bulgaria are at least fourfold.

i) Access to Private Capital. The attraction of both foreign and domestic private capital will increase investments in Bulgaria and reduce the debt burden of the NEK. By integrating Bulgaria's power sector into the international capital markets, the ability of NEK to modernize and meet its expansion plans will be enhanced.

ii) Transfer of Optimal Technologies. With the infusion of foreign investment will come the application of state-of-the art technologies that will enable the Bulgarian electric company (NEK) to improve the quality of service and operate in a more efficient and environmentally-sound manner. In addition, with private investments will come improved business management and accounting practices and expanded training and development of Bulgarian workers.

iii) Expanded use of Renewable Energy and Cogeneration. An independent power policy framework will induce private companies and industry to cost-effectively expand Bulgaria's indigenous renewable energy and cogeneration capacity in a way that could reduce Bulgaria's dependence on imported energy and hard currency requirements. These facilities could provide electricity at a price that is below NEK's avoided costs and would offer environmental benefits.

iv) Competition Leading to Minimized Costs. The competition fostered by independent power not only induces private developers to generate power at competitive costs but also provides important benchmarks for the NEK in determining the costs of new generation capacity.



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The effective restructuring of the Bulgarian power sector from central planning and subsidies to market economics and financial viability will be greatly facilitated by the above benefits.

### b) Essential Independent Power Policy and Institutional Conditions

The transmission of electric power represents a naturally-monopolistic market that must be subject to government regulation to prevent a utility from earning excessive monopoly profits. The policy and regulatory framework defined by the government and the electric utility are critical factors in establishing the price of electric power and therefore the return on investment in power projects. Independent power developers and investors therefore examine the policy, institutional, and regulatory framework before making investments in a particular country's power sector. On a contractual basis, individual projects can be developed without the entire policy and institutional framework being in place. Nonetheless, in order to develop a mature and competitive independent power industry with a diverse array of participants, this framework will be essential.

In the increasingly global marketplace, countries must compete against each other to attract the necessary capital and power project development capability. The independent power policy and institutional framework of Bulgaria relative to other countries worldwide will play a critical role in determining the success of Bulgaria's independent power program. The key lessons learned from the experience in other countries in general and the specific case studies described above point to three important independent power policy conditions.

- **Fair Process:** The process of selecting specific developers and projects needs to be as fair and transparent as possible. The developer and investors should be given a clear idea of who the key decision makers are and what specific requirements must be met. If the process is overly confused or political, it is unlikely that NEK will attract the kind of quality developers and investors it wants.

- **Fair Price:** The power purchase price offered by the utility needs to be fair and reflect the market price for generation. Unlike a government-owned utility, an independent developer cannot subsidize or reallocate costs of generating power. Without a fair market rate for the power, the independent generator will not be able to earn the revenues needed to service its debt and earn the required return to its investors.

- **Fair Terms:** The terms of the power purchase contract and other agreements need to incorporate certain other key elements necessary to reduce risks that the investors or lenders are unable or unprepared to take. The contract term needs to be of sufficient length (typically 20 - 25 years for a thermal project, and longer for a hydro project) in order to enable the project owner to service its debt. The structure of the buy-back rate and the energy and capacity commitments need to be spelled out clearly. The developer needs to be given appropriate guarantees that the government and utility will honor all its contractual and incentive commitments.



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These three points summarize the essential elements of an effective independent power policy and institutional framework. These issues will be addressed in greater detailed and applied to the Bulgarian context in Chapters IV and V.

## III. INDEPENDENT POWER MARKET POTENTIAL IN BULGARIA

### 1) Status of Bulgaria's Economy

#### a) Macro-Economic Conditions

During the communist era between World War II and the fall of the Soviet Union in 1989, Bulgaria made a major transition from an agricultural to an industrial economy. This economy, however, was largely dependent on subsidized energy from, and on markets in, the former Soviet Union (FSU). The collapse of the old communist order and the Council of Mutual Economic Assistance (CMEA) has hit Bulgaria with a double crisis. As energy prices quickly approached world market levels, Bulgaria's highly-inefficient economy has been hit with a dramatic increase in energy-related costs. At the same time, the markets for Bulgaria's traditional products have dropped precipitously, as the economies of the FSU and the Eastern Bloc have experienced economic decline. Bulgaria has been forced to follow the pattern throughout much of the Eastern Bloc, i.e. a dramatic decline in GDP. In 1990, Bulgaria's GDP declined 11.3% and in 1991, GDP declined a further 22.9%. These GDP figures, however, should be used with caution. The true size of Bulgaria's GDP is in question; estimates are that some 20% - 40% of total economic output is in the informal sector, and thus is not officially recorded.

According to US Department of Commerce statistics, inflation was around 50% in 1990 declining to around 35% in 1991, only to rebound to an estimated 65% in 1992. According to the EBRD, it is estimated that inflation will increase to between 80% and 120% in 1993. A large part of this inflation, however, is due to price increases mandated by the government to reduce or eliminate subsidies. This type of inflation is regarded as temporary and should result in a subsequent decline in inflation. Given the high inflation rates, commercial banks are only lending over short terms not to exceed one year and at high interest rates of over 60%.

A distortion exists in the freely floating Bulgarian leva exchange rate. Despite strong inflation, the leva has not devalued appreciably. Between 1991 and 1993, the leva has only depreciated from around 18 levas/US$ to around 25 levas/US$, despite annual inflation of between 35% and 80% during this same period. This distortion in the exchange rate is in part attributed to a low demand for dollars resulting from Bulgaria's economic downturn, the lack of disposable income on the part of many Bulgarians, and the high Bulgarian interest rates. Under these current conditions, foreign companies have had no problem repatriating profits or revenues in hard currency. When the economy turns around, however, a significant correction in the exchange rate could occur.

Bulgaria's foreign debt had doubled between 1985 to 1990, reaching about US$ 11 billion in 1991. Over 80% of this foreign debt is owed to commercial banks. Bulgaria has successfully renegotiated its sovereign debt with the Paris Club, but remains at an impasse regarding its commercial debt with the London Club (primarily to banks from European



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countries such as Austria, Germany, etc. and with only a small US bank component). Bulgaria's commercial debt is currently trading at around 0.18 to the US dollar. To date, a major impasse exists between the debt price the commercial banks want and what the Government of Bulgaria is willing to agree to. In the absence of a resolution of these debt negotiations, commercial banks will be very reticent to lend beyond the usual short-term trade financing.

The major multilateral lending institutions are active in Bulgaria. As part of a radical and comprehensive reform program launched by the coalition government in 1991, the IMF provided a US$ 279 million Stand-by Arrangement for an external contingency mechanism to maintain crude oil and natural gas prices. Also in 1991, the World Bank agreed to a US$ 250 million Structural Adjustment Loan (SAL) and a Technical Assistance Loan of US$ 17 million. Total IMF and G-24 financial support in 1991 was about US$ 1.6 billion. The IMF is negotiating with the Government of Bulgaria on further assistance that will help it in its negotiations with the London Club on the commercial debt. The IMF is pushing the GOB to keep the inflation rate below 50% - 60% and the GDP decline below 5%, which is well below the 80% - 120% inflation and 10% to 15% GDP decline expected for 1993.

In April 1993, the Bulgarian Cabinet approved a three year investment program totaling 93,499 million leva (approximately US$ 3.6 billion) between 1993 and 1995. Approximately 60% (59,106 million leva) of this budget will come from external sources, with the World Bank, EBRD, and European Investment Bank making substantial commitments. This program has identified 49 priority projects in bridges, water supply, rail transport, health care, environmental protection, electric power engineering, etc.

### b) Overall Business Climate

Over the past two years, the difficulties of converting an inefficient industry based on former communist block markets to markets in the West, the ensuing decline in Bulgaria's GDP, the high inflation and interest rates, the unresolved commercial bank debt negotiations, and the very limited and short term commercial lending clearly pose formidable barriers to investment. The general recession in the world economy and the Gulf and Yugoslavian wars have also particularly hurt Bulgaria's prospects for a quicker transition to a market economy.

While the current business investment climate is facing difficulties, Bulgaria has very attractive prospects in the future. Bulgaria has enacted laws that establish far reaching rights for private investors, including 100% foreign ownership, national treatment of foreign firms, and repatriation of profits (these laws are discussed in greater detail in Chapter IV). Bulgaria is endowed with a strategic trading position on the Balkan Peninsula, a well educated and skilled work force, certain elements of a good infrastructure, rich agricultural land, and attractive tourist resorts in the mountains and along the Black Sea.



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Like most Eastern European countries, Bulgaria has embarked on a privatization program. The Privatization Agency has been established with a staff dedicated to identifying and packaging the most attractive companies for public sale. The focus of this privatization program has been on those light manufacturing and agricultural industries (e.g. food processing, electronics, textile, etc.) that are potential export businesses which would earn the foreign exchange needed by foreign investors. As is true throughout Eastern Europe, the progress in privatizing companies is proceeding more slowly than hoped. Nonetheless, the first recent privatization of a "maize" (corn chip) products company, Tsarevichni Produkti, was sold to the Belgian company G.R. Amylum N.V. (80%), the United Bank of Bulgaria (18%), and company employees (1%) for US$ 45 million. This first privatization is seen as a promising development that hopefully will set a trend. The Privatization Agency expressed a particular interest in expanding industrial cogeneration at specific steam requiring industries being privatized. It has been reported that this maize company just privatized in fact has a cogeneration plant that the new owners do not want to use and which they would be willing to sell to an independent developer.

## 2) Overview of Bulgaria's Power and Energy Sector

### a) Existing Energy Resources

Bulgaria is endowed with limited energy resources and has typically had to import about 80% of its total energy needs. The country has only a very limited amount of oil, significant reserves of low grade brown coal, and some hydro resources.

Reserves of oil and gas have been declining and are currently at an estimated 3 million tonnes of oil equivalent, which would provide only about 3 months coverage at Bulgaria's current consumption levels. Exploration for oil around the Black Sea coast holds some hope of expanding these reserves.

Coal reserves at currently active coal mines are at about 2.6 billion tonnes, with lignite accounting for about 90% and sub-bituminous and bituminous coal comprising about 10%. The bituminous coal is dispersed and generally uneconomic to extract. The lignite reserves, on the other hand, are mostly concentrated at Maritsa East (southeastern Bulgaria). These reserves are found in relatively favorable mining conditions: easily accessible terrain, low overburden to lignite ratio, thick seams, and no groundwater problems. These lignite reserves are sufficient to meet the fuel requirements of 2,300 MW of power generating capacity at three power plants (Maritsa East 1 - 3) and a briquette factory for about another 75 years. This lignite, however, is of poor quality with a heating value of 1,500 kcal/kg and 2% sulfur. The Bobov Dol 630 MW power plant is located at an indigenous brown coal mine south of Sofia. Imported black coal from the Ukraine currently supplies the Varna (1,260 MW) and Russe (400 MW) power plants, with other sources being explored.



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There are significant hydropower resources that remain to be exploited. With 1970 MW of current installed hydro capacity, Energoproekt estimates that this represents only about 33% of the total exploitable resource. It is estimated that about 2,800 MW of economically exploitable capacity remain to be developed at various micro, mini, and large hydro sites. As is typical with hydro, this capacity experiences seasonal fluctuations due to rainfall and has limited dispatchability. Nonetheless, the availability of precipitation is heaviest during the NEK's highest winter power demand period.

Oil, gas, and coal prices were heavily subsidized during the old communist era. While these subsidies have been reduced substantially, particularly for oil, some level of subsidy still exists. The World Bank in its 1992 Energy Strategy Study points out that the price for the most economic Maritsa East coal is $0.6/GJ, while the real cost of production is about $1.1/GJ. On the other hand, the cost of imported natural gas from Russia is considered to be higher than the world market price. The World Bank points out that Bulgargaz was paying US$104 per thousand cubic meters for gas from Russia in 1991, when the world price was closer to $90 - 95 / 1000m3. This distortion is attributed to a non-cost based mechanism for pricing gas that vulnerable to fluctuations in index prices based on fuel oil and the dollar/leva exchange rate. The World Bank views these continuing distortions and subsidies in energy prices as not sending the right price signals in the Bulgarian energy sector.

**b) Existing Power Capacity**

The Natsionalna Elektricheska Kompania (NEK) is responsible for generating, transmitting, and distributing electricity to the entire country of Bulgaria. The Committee of Energy (COE) is the Bulgarian government committee which overseas NEK, the district heating companies, and the coal mining sector. Although the NEK is still wholly-owned by the government, efforts are being made to make it a profitable, financially independent organization that could be privatized in the future.

NEK provides electric power from a diverse fuel mix that in 1991 included 3,760 MW of nuclear power, 2,440 MW of indigenous lignite power, 1,970 MW of hydropower, 1,660 MW of imported coal power, and 630 MW of indigenous brown coal capacity. A listing of the name, size, and fuel of the major power plants is found in Table 1. Of the total installed electric generating capacity in Bulgaria, 86.6% is owned by NEK (10,460 MW); 4.8% by independent, limited liability district heating companies (1045 MW); and 8.6% by industry (577 MW). In all, a substantial proportion of NEK's generating capacity (over 13%) is provided by independent power producers (IPP's).

While NEK has 12,074 MW of total installed capacity at its disposal, over the last several years it has had difficulty meeting a system peak load of 7,200 MW. Most thermal plants are aging and poorly maintained, resulting in production at only 60 - 80% of their design output. Coal supplies from the former Soviet Union have been unreliable, as have been supplies from Bulgaria's own coal mines. Safety problems at the Kozloduy nuclear plant have



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| NEK INSTALLED AND OPERATIONAL POWER CAPACITY 1992 | | | |
|---|---|---|---|
| **Thermal Plants** | **Fuel** | **Operational Capacity (MW)** | **Installed Capacity (MW)** |
| Maritsa East I | lignite | 172 | 200 |
| Maritsa East II | lignite | 1,080 | 1,230 |
| Maritsa East III | lignite | 780 | 840 |
| Varna | imported coal and gas | 1,260 | 1,260 |
| Bobov Dol | brown coal | 570 | 630 |
| Russe | imported coal | 310 | 400 |
| **Total Thermal Plants** | | 4,172 | 4,560 |
| Kozloduy Nuclear Plant | | 1,811 | 3,760 |
| Hydropower | | 1,600 | 1,970 |
| **Total Capacity** | | 7,583 | 10,290 |

*SOURCE : NEK, 1993*

Table 1

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required the shutdown of two units so that new safety equipment can be installed. And finally, production from hydro plants has been affected by a period of dry weather. In 1992, a total of 38.24 TWh was generated. NEK generated 30.88 TWh. District heating plants and industrial generators produced 4.66 TWh and the remainder, 2.70 TWh, was imported from other countries.

### c) District Heating and Industrial Cogeneration

Most major cities and towns in Bulgaria have well-developed district heating systems. These systems provide steam and hot water to industries and households. Like the power plants, many of the systems are old, poorly maintained and have inefficient boilers and distribution systems. Boilers in the larger systems run on natural gas, fuel oil or coal and associated generators provide electricity to the grid under contracts with NEK. A summary list of the 10 major district heating plants that have power generation facilities is found in Table 2.

Likewise, there are some 9 major industrial cogenerators with a capacity greater than 10 MW, as shown in Table 3. These include large petroleum and petrochemical plants, two chemical plants, a metallurgical plant, a tire and fabric plant, and a fertilizer plant. Fuels for these cogeneration plants include gas, coal, and fuel oil. These cogeneration facilities primarily produce steam for the thermal loads of the factories and generate power as a byproduct for reducing part or all of the power demand from NEK. Some of these cogenerators sell surplus electricity back to the grid.

A visit to two of the cogenerators (i.e. the Kremikovtzi steel mill and the Chimco Vratsa chemical plant) revealed that some cogenerators only meet part of the captive electricity needs with no sales to the grid. Kremikovtzi is able to generate power cheaper than NEK due to the availability of low cost gas byproducts from steel production. Expanding cogeneration to generate excess power for sales to the grid was deemed presently uneconomic at Kremikovtzi, since it would require supplementing the limited by-product gas supplies with high-priced imported gas. At Chimco Vratsa the economics of cogeneration just to meet captive needs is barely viable given the high natural gas prices, possible generation inefficiencies, and the relatively low NEK tariffs. Nonetheless, NEK indicated that some of the cogenerators are delivering surplus power to the grid. These cogenerators include Burgas, Devnia, Svishtov, NHK Pleven, and Vidin.

The current power sales terms between NEK and industrial or district heating cogenerators are not sufficiently attractive to induce investments in new cogeneration capacity. The power purchase contracts are for no longer than one year and offer prices below NEK's full cost of generation (these contract terms are discussed in greater detail in Chapter IV). Under these one year contracts, the district heating or industrial cogenerators are not obliged contractually to meet availability or reliability criteria or to generate minimum levels of



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| BULGARIAN DISTRICT HEATING PLANTS WITH ELECTRIC POWER GENERATING CAPACITY | |
|---|---|
| **Town** | **Installed Capacity (MW)** |
| Sofia | 95 |
| Plovdiv | 65 |
| Russe West | 3 |
| Pleven | 24 |
| Shumen | 12 |
| Traicho Kostov | 132 |
| Sliven | 22 |
| Kazanlak | 10 |
| Gabrovo | 12 |
| Republika | 88 |
| TOTAL | 463 |

*SOURCE : COMMITTEE OF ENERGY, 1992*

Table 2

## MAJOR INDUSTRIAL COGENERATION PLANTS IN BULGARIA - 1991

| No. | Name of Power Plant | Fuel (MW) | Installed Capacity (MW) | Maximum Available Capacity (MW) | Annual Electricity Output (GWh) | Annual Heat Output (Tcal) | Annual Fuel Consumption Thous.tce |
|---|---|---|---|---|---|---|---|
| 1 | NHK - Burgas | residual, natural gas | 257 | 160 | 949 | 3046 | 568<br>119 |
| 2 | Devnia | imp.coal, residual | 219 | 100 | 634 | 3200 | 207<br>18 |
| 3 | Swishtov | imp.coal | 120 | 60 | 498 | 435 | 250 |
| 4 | Kremi-kovtzi | natural gas | 112 | 80 | 527 | 795 | 282 |
| 5 | NHK - Pleven | residual, natural gas | 60 | 45 | 291 | 1194 | 127<br>50 |
| 6 | Vidin | imp.coal | 60 | 50 | 273 | 567 | 283 |
| 7 | Vratza | natural gas | 60 | 40 | 200 | 1258 | 198 |
| 8 | Stara Zagora | lignite, natural gas | 48 | 32 | 52 | 835 | 67<br>84 |
| 9 | St.Kara-zhiev | residual | 26 | 10 | 43 | 703 | 92 |

*SOURCE : NEK, 1992*

Table 3

energy. Under these conditions, these facilities could not be regarded as firm capacity that is dispatchable by NEK and thus could not expect payments for capacity delivered.

### d) Expected Needs for Electricity and Capacity

#### i) Electricity Demand Forecast

As occurred in many of the planned economies of Eastern Europe and the former Soviet Union, there was rapid development of the power sector in Bulgaria through the mid to late 1980's to accommodate an expanding but inefficient heavy industrial base. The sudden transition to market economics, the collapse of former communist bloc markets, and the wars in the Gulf and Yugoslavia have led to a dramatic decline in economic and industrial output and electricity demand over the past several years. Electricity demand is expected to "bottom out" in 1992 and 1993 and then begin increasing slowly.

The graph found in Figure 4 shows NEK's different demand forecasts scenarios based on projections made in 1984 (under the old communist order), 1990, and minimum, intermediate, and maximum projections in 1992. As this graph shows, there was a dramatic decline in electricity demand below the 1984 projections, with two precipitous drops around 1985 and 1990. The forecast of electricity demand found in Table 4 (which was prepared by the World Bank and accepted by NEK) is very close to the intermediate demand forecast shown in Figure 4 and appears to be a reasonable forecast of electricity and peak power capacity demand between 1992 and 2010. Therefore, we have used the 1992 intermediate demand forecast is used in the capacity expansion plan discussed below.

Load forecasts should be used with caution. Economic predictions are especially hazardous for Bulgaria and other Eastern European countries because there is no experience with large scale conversions from planned to market economies. It is too early to know whether various industries could become competitive on the world market. Major shifts could occur from energy-intensive industries like chemicals and metallurgy to lighter industries that are less energy-intensive. Furthermore, the current forecast does not account for price elasticity and so the impact of household consumption on load could be overestimated. In addition, the potential impact of demand-side management or energy efficiency programs is uncertain. Use of these forecasts for investment decisions involves considerable risk, which both NEK and IPP developers must consider.



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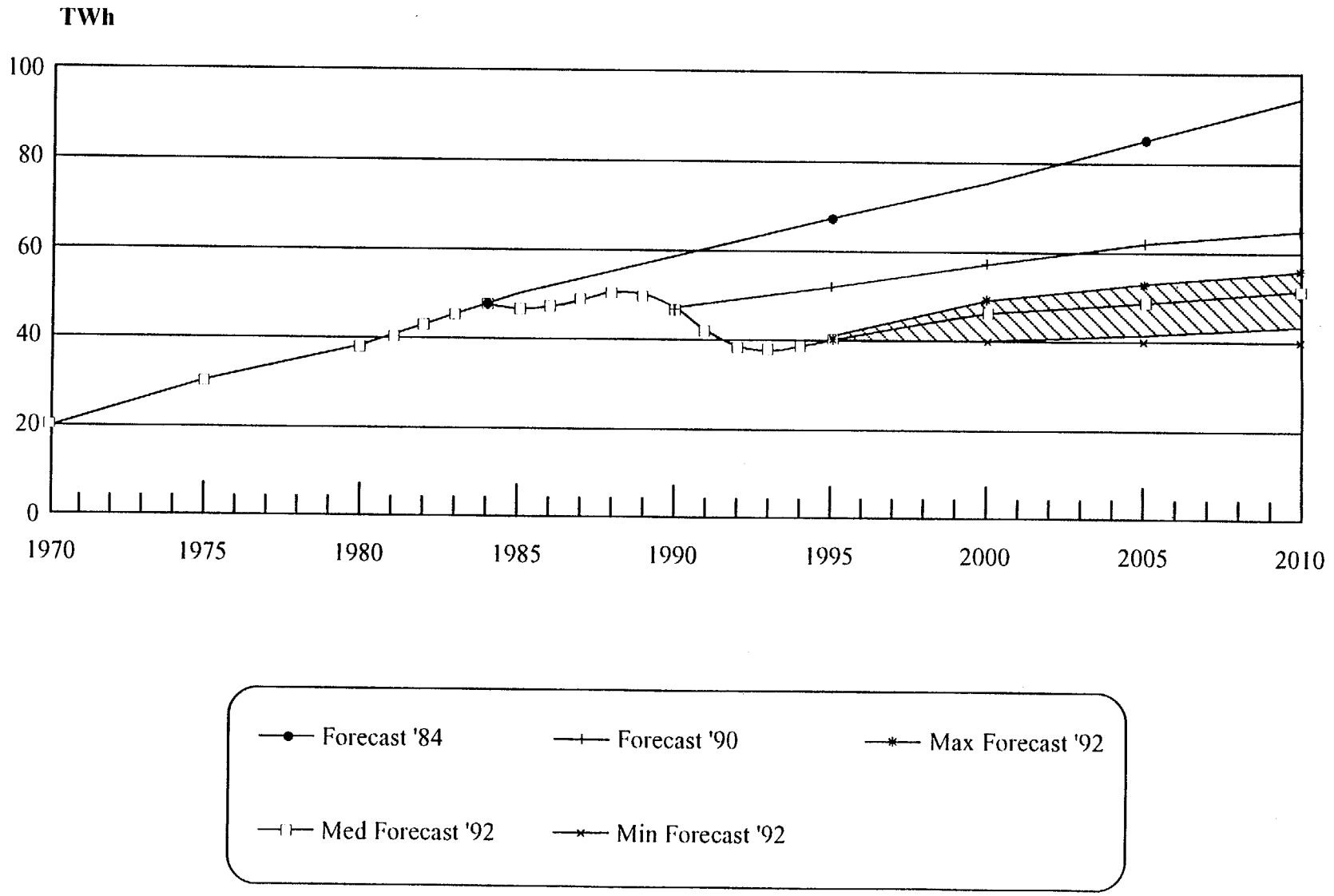
# Bulgaria Electricity Demand Forecasts




Source: NEK, 1992

Figure 4

| HISTORY AND MEDIUM FORECAST OF ELECTRICITY DEMAND | | |
|---|---|---|
| YEAR | TWh | MW |
| 1989 | 48.64* | 8332* |
| 1990 | 45.91* | NA |
| 1991 | 41.00* | NA |
| 1992 | 38.22* | 6870 |
| 1993 | 38.30 | 6840 |
| 1994 | 38.50 | 6870 |
| 1995 | 40.50 | 7230 |
| 2000 | 46.00 | 8070 |
| 2005 | 49.00 | 8600 |
| 2010 | 52.00 | 9120 |
| * Actual | | |

Table 4

**ii) Capacity Expansion Plans**

NEK has prepared an expansion plan projecting capacity installations and needs between 1993 and 2010, as shown in Table 5. This expansion plan is based on the intermediate electricity and peak power demand forecast accepted by the World Bank and NEK, as discussed above. This capacity expansion includes projects currently being implemented by NEK, including the completion of the Chaira pumped storage facility which will provide 864 MW of peaking capacity and the Maritsa East II, (Unit 8) coal plant which will provide 210 MW of base load capacity. These two projects have been funded by the World Bank and the European Bank for Reconstruction and Development, respectively.

Based on the medium demand forecast, NEK's current generation expansion plans forecast the need for 880 MW of new capacity by the year 2000 and 3,940 MW by 2010. Options for meeting these capacity requirements include the use of indigenous coal, indigenous hydro, imported coal, imported gas, and nuclear. Specific options will be discussed in the next section. After the year 2000, NEK's alternate plan recommends that consideration be given to construction of a new nuclear facility and a major hydropower facility on the Danube River.



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# Capacity Balance Forecast for Bulgaria Power System

(Megawatts)

| Source Types | Year | | | | | |
|---|---|---|---|---|---|---|
| | 1993 | 1994 | 1995 | 2000 | 2005 | 2010 |
| Electricity demand (TWh) | 38.0 | 38.5 | 39.5 | 46.0 | 49.0 | 52.0 |
| Peak load (MW) | 7100 | 7000 | 7180 | 8210 | 8750 | 9280 |
| Existing NPP | 2600 | 2600 | 2600 | 2600 | 2600 | 2600 |
| Existing TPP | 4937 | 4917 | 5226 | 5195 | 5155 | 5145 |
| Existing HPP | 1200 | 1200 | 1200 | 1200 | 1200 | 1200 |
| Chaira project | 200 | 400 | 400 | 800 | 800 | 800 |
| Required new construction | 0 | 0 | 0 | 880 | 1620 | 2320 |
| Total available capacity | 8937 | 9117 | 9426 | 10675 | 11375 | 12065 |
| Reserve compared to peak load MW | 1837 | 2117 | 2246 | 2465 | 2625 | 2785 |
| Reserve compared to peak load % | 25.9 | 30.2 | 31.3 | 30.0 | 30.0 | 30.0 |

**NPP:** nuclear power plants
**TPP:** thermal power plants
**HPP:** hydro power plants

Source: NEK, 1992

Table 5

The World Bank recently prepared a report entitle Bulgaria Power Demand and Supply Options (May 1993) with the International Energy Agency for the G-7. This study was requested by the G7 in 1992 to examine alternative energy sources for replacing the less safe nuclear plants (VVER 440 model 230s) in Eastern Europe and the former Soviet Union. Bulgaria has 4 VVER 440 model 230 units # 1 - 4 at its Kozloduy plant with a capacity 1,760 MW out of the total plant capacity of 3,760 MW. The possible phase out of nuclear power capacity has significant implications for electric power planning and the potential role of independent power. Independent power developers are unlikely to have a role in nuclear generation. The phase out of some fraction of the nuclear capacity will create a greater demand for alternative power, which could open up significant IPP opportunities.

In this study, the World Bank developed various capacity expansion and investment projections using the Wien Automated System Planning Package (WASP) least cost expansion planning model. These forecasts were based on three different electricity demand projections and six difference nuclear power scenarios, ranging from shutting down all six units at Kozloduy immediately (Scenario 0) to keeping all units operational through the end of their designed life (Scenario 5). The scenarios involving continued nuclear power plant operation require between $678.0 and $1,566.8 million investments to upgrade the safety and performance of these units. The Bulgarian government has agreed to reduce its dependency on nuclear power over the long term.

The least cost alternative to nuclear power and option for capacity expansion involves the addition of new gas-fired combined cycle generating units at existing or new district heating and industrial cogeneration facilities. The installed cost for this new combined cycle capacity at existing cogeneration sites is projected to be between about $200/kW and $500/kW. The Government of Bulgaria has been concerned about the increased reliance on imported gas that these facilities would require. At their request, this study ran a scenario that limited gas imports for power and district heating to about 2 billion cubic meters per year (approximately current levels) and thus effectively eliminated the least cost expansion option involved gas-fired combined cycle systems. According to the World Bank analysis, this restricted gas consumption scenario effectively increased the cost of supplying power by about 3% - 8% (depending on demand and nuclear phaseout assumptions). The Government of Bulgaria will need to decide whether this possible increase in the cost of capacity expansion is justified to reduce dependence on imported gas.

The World Bank analysis concludes that the least cost alternative in the near-term involves investments in rehabilitating and repowering existing thermal power plants and district heating and industrial cogeneration facilities. Bulgaria's demand and capacity balance between 1993 and 2010 is shown in Figure 5 under two difference scenarios: (1) for a complete nuclear shut down (Scenario S-0) and (2) a complete nuclear rehabilitation (Scenario S-5). As is evident in these charts, by the year 2000, power and cogeneration plant rehabilitation/repowering could potentially contribute between 2,000 and 3,000 MW. In contrast, only 0 to 1,000 MW of new capacity additions are indicated.



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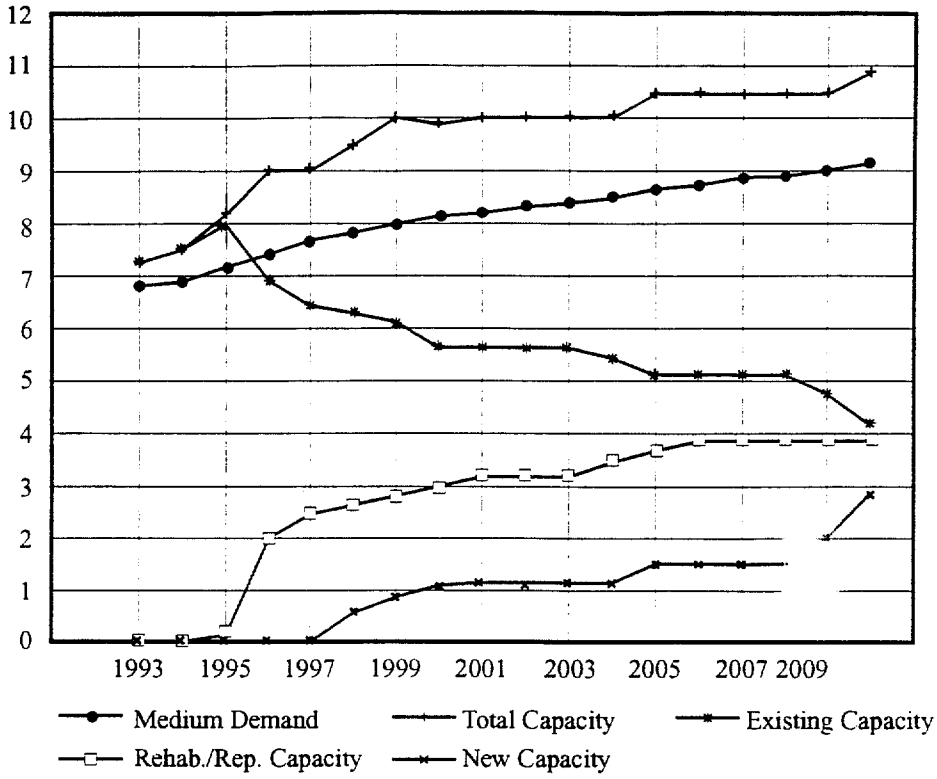
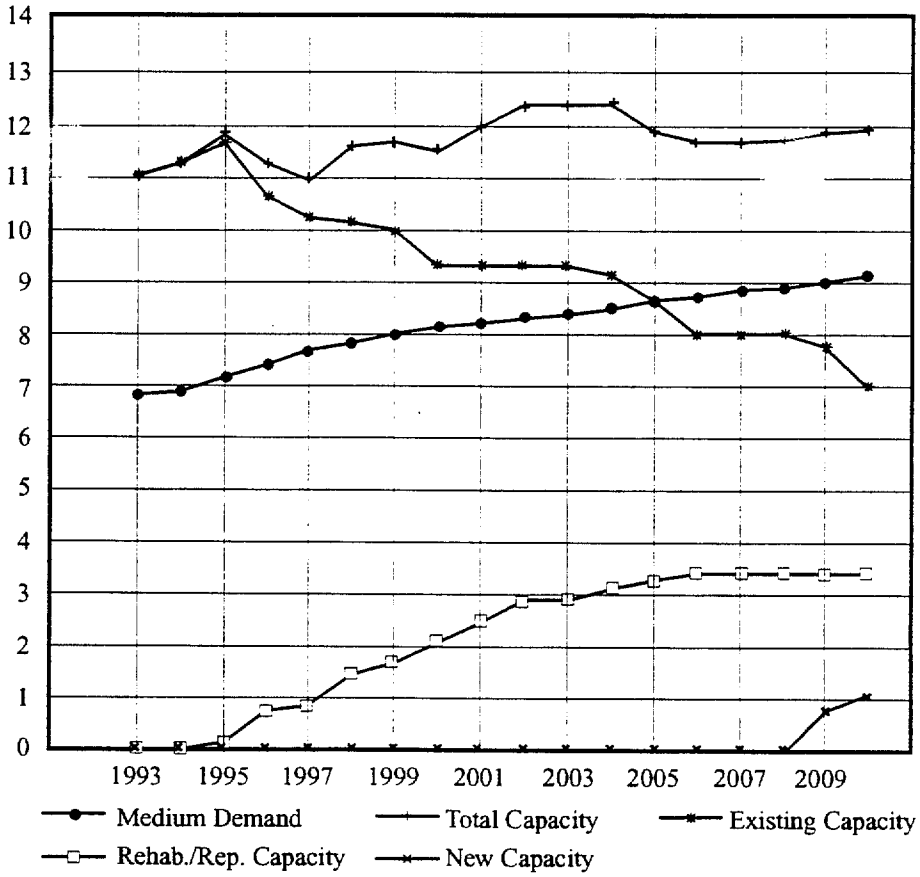
## Bulgaria: Demand - Capacity Balance

Medium Power Demand and Nuclear Scenario 0




## Bulgaria: Demand - Capacity Balance

Medium Power Demand and Nuclear Scenario 5




Source: World Bank, *Bulgaria Power Demand and Supply Options*, May 4, 1993.

Figure 5

The analysis prepared by the World Bank is preliminary and will be refined by additional demand side and least cost utility planning being implemented. US AID and the European Community (EC) are currently cooperating in the development of a least-cost power supply plan for Bulgaria. This study will bring together a number of studies in an effort to provide a more comprehensive plan for generation expansion and demand-side management. A clear definition of the least cost expansion options will result from this ongoing analysis.

One of the studies that will be included in the least-cost plan is a detailed feasibility analysis of the rehabilitation of six thermal power plants. This study is funded by the US Trade and Development Agency (TDA) and is being implemented by Bechtel. The upcoming report will provide useful information on potential rehabilitation, repowering, and retirement of the major central thermal power plants.

When it is completed, the least-cost plan will provide a very detailed analysis of electricity demand and options for capacity expansion and demand-side management. It is important to note that if Bulgaria experiences low economic growth, demand-side management and energy efficiency measures prove effective, and some 450,000 households are successfully converted from electricity to gas heating (i.e. the low demand forecast scenario), no additional capacity expansion will be required until the year 2000 and possibly as late as 2005. The uncertainty in the demand forecast and expansion plans requires that such plans be continuously updated to reflect current economic and electricity demand data. The focus under most scenarios will be on the rehabilitation and repowering of existing thermal units, whether they be central power plants or industrial and district heating cogenerators.

### e) Financial Status of Power Sector

#### i) electricity pricing

The average electricity tariff is set by the Council of Ministers (COM), with the Commission on Prices (COP) and the Committee of Energy (COE) defining the structure of the tariffs (for a further discussion of these institutions, see chapter IV). In May 1990, a uniform tariff structure was instituted that is consistent with the principles of marginal cost pricing. This tariff differentiates customers on the basis of high (> 35 kV), medium (10 kV - 35 kV), and low voltage (< 10 kV) levels and according to different times of the year (winter and summer) and different times of the day (peak, day, and night).

There have been major increases in the average tariff from 0.0524 leva/kWh in late 1990 to 0.64 leva/kWh in January 1993. In May 1993 a further tariff increase was instituted as shown in Table 6. According to the World Bank, this May 1993 increase has raised the average tariff to about 2.9 cents/kWh. This rate is still considered too low. The World Bank and NEK have agreed that before September 1, 1993 the average price will be increased to 3.5 cents/kWh. After more detailed financial and cost analysis has been performed (which is expected before September 1994), the average price will be set at the greater of the long run



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| NEK ELECTRICITY TARRIFS<br>MAY 1993<br>(leva/kWh) | | | | | | |
|---|---|---|---|---|---|---|
| **Time of Day** | **Winter Period** | | | **Summer Period** | | |
| | **Level of Voltage** | | | **Level of Voltage** | | |
| | hv | mv | lv | hv | mv | lv |
| Peak | 1.472 | 1.527 | 1.598 | 1.284 | 1.324 | 1.389 |
| Day | 0.799 | 0.826 | 0.863 | 0.691 | 0.716 | 0.750 |
| Night | 0.359 | 0.407 | 0.427 | 0.340 | 0.351 | 0.369 |
| One-scale Measurement | 1.187 | 1.225 | 1.285 | 1.032 | 1.064 | 1.116 |
| The approximate exchange rate in May 1993 was is 26.4 Leva per US$ | | | | | | |

*SOURCE : NEK, 1993*

Table 6

marginal cost or the average price necessary for NEK to achieve a debt service coverage ratio of 1.5.

Residential household tariffs are substantially lower than for all other customers due to a major subsidy. While industrial tariffs have approached NEK's cost of generation, residential tariffs have been significantly lower. In the May 1993 tariff increase, residential rates were increased 50% while industrial rates were only raised 5.5% to partially reduce this cross subsidy. Household consumers, however, are being hard hit by these rate increases, given the low wages of many Bulgarians (particularly senior and other citizens on fixed incomes). There are discussions of providing some kind of social safety net to help those residential customers most in need. Given the very limited financial resources of the government, the source of funds for such a program is hard to identify.

**ii) utility financial performance**

In the long term, the government may consider privatizing NEK. Currently, however, the financial performance of NEK and the lack of an appropriate energy policy and institutional framework would make NEK less attractive to investors. Over the past few years, NEK has been operating with inadequate cash flows and high current liabilities. In 1992, NEK had losses of 2.45 billion leva on total revenues of 15.40 billion leva. In 1991, losses were around 1.39 billion leva on total revenues of 9.56 billion. These losses are being covered through state support. The Ministry of Finance (MOF) has given NEK a timetable in which to eliminate this need for state subsidies. The goal agreed to between the MOF and NEK is that by 1995, NEK will be earning a positive net income and that state subsidies will end. The World Bank and NEK are working together closely to achieve this objective.

Given the recognized inability of NEK to service its debt, most of its earlier liabilities were forgiven and removed from its books. Without having to service its debt on the amortization of previous installed capacity, it will be significantly easier for NEK to turn a profit in the near-term. However, as additional investments in repowering, rehabilitation, or new capacity are required over the coming years, NEK will need to raise its tariffs to reflect the capital recovery costs. Even after all of the tariff increases made so far and contemplated before the end of 1993, an independent power purchase rate based at or below the existing industrial tariff may not be sufficient to enable an independent power developer to recover the full capital, operating and maintenance, and fuel costs of a new power installation. This actual cost of generation issue will need to be examined closely as COE's and NEK's independent power policy framework is developed.

The current goal is to establish the needed policy and regulatory framework so that appropriate tariffs and price signals can be established in the market place. In addition, assistance is being provided to COE and NEK in applying market-oriented financial and accounting principles. The schedule of these activities should put NEK in a relatively attractive condition by early 1995. By developing a favorable independent power policy



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program in parallel with these activities, it is very conceivable that independent power projects could be successfully initiated within this time frame.

### 3) Review of Potential Independent Power Configurations

There are various configurations and options for independent power development that could occur in Bulgaria. These include:

- **Industrial Cogeneration**: Those industries that particularly require substantial quantities of steam or hot water for their production process (e.g. pulp & paper, petrochemical, steel, food processing, etc.) are prime candidates for cogeneration and independent power.

- **District Heating Cogeneration:** District heating plants that supply steam and hot water to municipalities and industry are also prime candidates for cogeneration and independent power.

- **Thermal and Hydro Plant Repowering**: Existing thermal and hydro power plants that are in need of considerable rehabilitation or repowering could be sold in part or in their entirety to private developers, who will make the necessary improvements and/or expansions.

- **New Thermal and Hydro Power Projects**: New capacity requirements could be supplied by private developers building new thermal and hydro power projects.

District heating systems and industrial cogenerators may offer the opportunity for providing increased capacity and energy to the grid either through repowering existing facilities with expanded power output capacities or through construction of new generating plants at new industrial sites. Industries could be encouraged to self-generate and reduce power demand through appropriate power pricing terms. The viability of cogeneration projects clearly depends on the commercial viability of the underlying industrial or district heating business and on the power purchase contract terms offered by NEK (i.e. buyback rate and contract term).

Some of the existing thermal power plants are in major need of rehabilitation or repowering in order to optimize their technical and financial performance. The Government of Bulgaria is severely constrained in its ability to finance these improvements and may want to attract private capital for this purpose. In order to induce the private sector to invest, NEK may wish to consider selling all or part of some of these thermal power plants. A joint venture between NEK and a private developer could be proposed or the power plant could be sold to



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the private sector outright. New stand-alone independent power plants built by private developers, when needed, could sell electricity to NEK or directly to large retail customers.

The development of Bulgaria's substantial indigenous hydro resources could also present attractive opportunities for independent power developers. Energoproekt's Hydropower Division has performed an extensive study of the potential for new hydro development. There are major hydro sites being developed such as the Chaira pumped storage hydro plant being completed with funding from the World Bank. Energoproekt has identified about 155 mini-hydropower sites totaling 2,599 MW and 738 micro hydro sites totaling 215 MW. Some of these sites have as much as 1000 feet of head, which could result in a very attractive installed cost per kiloWatt.

The long term need for major new central station power capacity using coal, oil, gas, and hydro after the year 2000 will also lend itself to independent power development. By this point, some smaller IPPs should have been developed thus establishing the procurement, contractual, and permitting precedent.

### 4) Estimate of Bulgaria's Independent Power Market Potential

The ability to make a market estimate for independent power is constrained by two major uncertainties. First, the demand for electricity and the power expansion needs are unclear due to Bulgaria's difficult economic transition. With the recent declines in electricity demand and surplus capacity of variable reliability, Bulgaria could possibly postpone making major new investments in the non-nuclear power sector for a few years. Within the next 5 to 10 years, however, major new investments in cogeneration and power plant rehabilitation and expansion will be required. Second, the extent to which a favorable business investment climate for independent power will develop is unclear. Independent power developers will only play a role in new capacity investments if the Government of Bulgaria, COE, and NEK implement policies and pursue strategies that encourage and facilitate private investment (as explored in Chapters IV and V). Given that these policies are in the formative stage, there is considerable uncertainty as to their outcome.

Given these caveats, it nonetheless is possible to provide an estimate for the independent power market and describe the potential independent power opportunities that could potentially develop. As discussed in the capacity expansion plan section and shown in Figure 5, the World Bank estimates that between 0 and 1,000 MW of new capacity will be added between 1993 and 2000 and between 2,000 MW and 3,000 MW will need to be rehabilitated or repowered (based on the extremes of nuclear power scenarios 0 through 5). Assuming the most likely moderate nuclear power scenario # 3, this report estimates that investments totaling about $ 521 million will be required for power capacity rehabilitation and repowering and $474 million investments will be need for new capacity between 1993 and 2000.



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Given the capital constraints of the GOB, it is fair to assume that some proportion of those additions will be offered to the private sector. The extent to which private investors will respond will depend on government policy, the overall investment climate, and the extent to which Multilateral Banks and Export Credit Agencies join the private sector in enabling the first precedent-setting independent power projects. A summary of these potential opportunities is discussed below and is provided in Table 7.

**a) District Heating and Industrial Cogeneration**

Private cogeneration could play an important role meeting the expanded capacity requirements in the near-term. In addition, as Bulgaria considers its economic development future, cogeneration could play an important part in improving the economic viability of certain industries and the district heating sector. For example, agricultural and food processing products are expected to be a major export industry for Bulgaria. Food processing and fertilizer plants both have a strong potential for cogeneration which could make these industries more competitive internationally.

Preliminary analysis is being conducted to determine the repowering and expanded cogeneration potential at the existing industrial and district heating cogeneration sites. In the World Bank G7 report, preliminary analysis has been performed based largely on the application of fluidized bed or combined cycle technology. This report indicates the potential for expanding the installed industrial cogeneration capacity to be around 560 MW to about 2,570 MW at the Burgas refinery, Kremikovtzi steel mill, Chimco Vratsa chemical plant, and the Stara Zagora fertilizer plant.

At the major district heating plants, the potential for expanding cogeneration from a total of about 610 MW to about 2,460 MW has been identified, with particular focus on the Sofia, Kostov, Pernik, Plovdiv, Avram Stoianov, Pleven, and Shumen district heating plants. Through US Trade and Development Agency funding, Gilbert Commonwealth of the US is currently undertaking feasibility studies of three district heating plants. This analysis will be a valuable first step in determining the potential for private investment. There has been discussion of transferring ownership of some district heating plants from COE to the respective municipalities. Given the major rehabilitation and repowering needs of these plants and the financial constraints at both the federal and municipal levels, private investment and management could be greatly needed.

If all these industrial and district heating cogeneration projects proved feasible, the potential for expanded cogeneration at these existing plants would total around 3,800 MW. This additional capacity would be able to supply most of the 4,820 MW of new capacity that the intermediate growth expansion plan calls for between 1993 and 2010. However, the expanded use of natural gas that many of these cogeneration projects call for has generated substantial debate. Many utility officials interviewed want to avoid increasing dependence on imported Russian gas, particularly at the current high price in Bulgaria. In addition, NEK



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# BULGARIA POWER PROJECT INVESTMENT OPPORTUNITIES

Estimates: June 1993

| Power Facility Name | Existing Installed Capacity (MegaWatts) | Potential New or Repowered Capacity (MegaWatts) |
|---|---|---|
| **Thermal Power Plants** | | |
| Maritsa East 1 | 200 | 200 – 250 |
| Maritsa East 2 | 1,245 | 1,245 – 1,455 |
| Martisa East 3 | 840 | 840 |
| Varna | 1,260 | 1,260 |
| Russe | 400 | 400 |
| Bobov Dol | 630 | 630 |
| **District Heating Cogeneration Plants** | | |
| Russe | 270 | 340 |
| Sofia | 125 | 345 |
| Kostov | 186 | 870 |
| Pernick | 155 | 130 |
| Plovdiv | 60 | 260 |
| Pleven | 36 | 295 |
| Shumen | 18 | 160 |
| **Industrial Cogeneration Plants** | | |
| Burgas | 220 | 1,082 |
| Kremikovtzi | 60 | 486 |
| Chimco Vratsa | 60 | 284 |
| Stara Zagora | 48 | 720 |
| Devnia | 60 | 616 |
| **Hydro Power Plants** | | |
| Danube River | | 400 |
| Gorno Arda | | 175 |
| Sredna Vacha | | 100 |

Source: World Bank, Bulgaria Demand & Supply Options, May, 1993; Energoproekt

Table 7

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would prefer to see imported gas used to convert 450,000 residential homes from electric to gas heating (thereby reducing their winter peak demand).

### b) Coal-Fired Power Plant Rehabilitation and Repowering

Power project rehabilitation involves repairing and replacing components of an existing design, while repowering involves a substantial reconfiguration and possible expansion of a power plant using improved technology. Major opportunities for both rehabilitation and repowering exist in Bulgaria.

Most of the major thermal (coal-fired) power plants in Bulgaria are in need of some form of rehabilitation or repowering, as is being studied by Bechtel in a Trade & Development Agency (TDA) funded feasibility study. This need is partially based on the age of the units and particularly on the type of technology used and the conditions they have had to operate under. Assuming that the useful life of these Bulgarian coal-fired units is 30 years, units totaling roughly 370 MW would need to be retired between 1993 and 2000. While thermal plants in the US can have a longer useful life, the Bulgarian coal-fired units have been subject to much harsher conditions and involve technology that is less well adapted to the efficiency and environmental criteria Western countries are stipulating as conditions for power sector loans. The power plant units that will exceed a 30 year life between 1993 and 2000 are 4 lignite-fired units totaling 200 MW at the Maritsa East 1 power plant and the 3 lignite-fired units totaling 170 MW at the Maritsa 3 power plant.

The coal-fired power plants that could be considered for replacement and repowering between 2000 and 2010 would add up to over 1,400 MW (again assuming a 30 year life). The power plant units that will exceed a 30 year life between 2000 and 2010 and thus are major candidates for retirement or repowering are 4 lignite-fired units totaling 600 MW at the Maritsa East 2 power plant, 3 imported coal and gas fired units totaling 630 MW at the Varna power plant, and 3 imported coal fired units totaling 170 MW at the Russe power plant. Clearly, the results of the TDA Bechtel study will better clarify the options regarding retirement and repowering of these units.

In order to attract private capital into rehabilitating/repowering existing power plants, NEK may need to consider selling off part or all of particular power plants or entering into joint ventures as is being implemented in Poland. Private developers and investors are unlikely to want to invest in a power plant that they do not have sufficient ownership and management control over. Selling part or all of a power project could also be a way for NEK to raise capital for various purposes.

The indigenous lignite burning power plants at the Maritsa complex (Maritsa 1 -3 power plants) are in considerable need of reconditioning and repowering. The poor quality of the lignite at Maritsa and the labor problems at the coal mines could be addressed by a



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Bulgarian government / private investor partnership that would provide the appropriate clean-coal technologies and labor management plan.

The two coal-fired power plants that are burning imported anthracite coal from the Ukraine, Varna (1,260 MW) and Russe (400 MW), are in better condition but still call for significant repowering. The reliability of coal supplies from the Ukraine has been a problem so analysis is being conducted on converting the boilers to burn imported sub-bituminous coal from Africa or Asia. If a reliable supply of coal is found that matches the boiler configuration, private investors might be more interested in these facilities.

The Maritsa East 1 power plant (200 MW) presents an interesting repowering case because it also supplies steam to the country's only major briquette factory. The Bobov Dol power plant (630 MW) has depleted its local source of coal and is being considered for boiler modification to burn blended coal or low sulfur imported coal.

A summary of the three power projects, Maritsa East 2, Varna, and Bobov Dol that the World Bank study identified as prime candidates for repowering is found in the Appendix. When TDA and Bechtel publish the results of their feasibility studies of repowering of all six thermal plants, the results of this analysis will reveal which projects have the best return on investment.

### c) Hydropower

It is not expected that any of the existing hydro plants will be retired (some are about 30 to 35 years old) but investment in upgrading to increase efficiency could be attractive. Energoproekt has identified about 2,800 MW of new, potentially-exploitable hydro resources. These new sites could offer some interesting investment opportunities. The NEK is interested in jointly developing with the Rumanians 400 MW of hydro capacity at Nikopol-Turnu Magurele and Silistra Kalarash on the Danube River. Other major hydro sites to be developed include about 175 MW at Gorna Arda and about 100 MW at Sredna Vacha. Given that the hydro generation would typically be during the peak winter demand months, these projects may fit into the least cost plan in an optimal way.

Given the high costs of developing a power project, foreign developers are likely to be primarily interested in the mini-hydro and larger hydro projects exceeding 5 MW to 10 MW. Many of the pre-closing development costs are the same for small projects as they are for larger projects, while the profits and revenues earned are a function of size. Developing a micro-hydro project on the scale of 100 kW would not generate the revenues typically required by a foreign investor to justify the project development costs.



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### d) New Capacity Additions

As discussed in the previous section, NEK has prepared an expansion plan based on low, intermediate, and high demand growth scenarios. Given the uncertainties in the world and the Bulgarian economy and power sector, these expansion projections are uncertain and will require careful examination and updating. These new capacity projections, nonetheless, do provide an estimate of the possible opportunities for new independent power project development.

If the intermediate demand growth scenario proves correct, 880 MW of new capacity will be required between 1993 and 2000. There is a range of options on how to supply this new capacity, if needed. One option for NEK would be to expand the capacity at the Kozloduy nuclear power plant. Given the difficulty Bulgaria will have in obtaining the financing for this expansion and the fact that it is unlikely that nuclear power could be developed under an independent power scheme, the focus of this discussion has been on conventional thermal and hydro facilities. The most attractive opportunities could be for expanded coal-fired, combined cycle gas-fired, and hydro project development both at central power plants and cogeneration facilities in industry and at district heating plants.

Over the long term, increased electricity demand and more plant retirements will definitely require the construction of new generating facilities. If the intermediate electricity demand growth scenario proves correct, the NEK expansion plan calls for 3,940 MW of capacity between 2000 and 2010. It is very likely that the Bulgarian economy will be on a sound market-based footing by this period and that economic growth could be strong.

There is a wide range of options for supplying these longer-term capacity requirements. At a later date, nuclear power may have found greater favor in the international community, given the growing air pollution concerns. Given the extensive development of Russia's large reserves of oil and gas, the expanded power capacity using these relatively clean fossil fuels may well be increased. Bulgaria's coal reserves and poor coal quality could well inhibit a significant expansion beyond current capacity levels with further imports of higher grade coal.

### e) Power Export Markets

Over the long term, COE and NEK might consider the potential market for exporting power to those neighboring countries that are deficient in power. The Bulgarian power transmission system is interconnected with all neighboring countries, including the Ukraine, Romania, Turkey, Greece, and Yugoslavia. Given the existing 750 kV and 400 kV link with the Ukraine, and the 400 kV links with all other neighbors, the basic infrastructure is in place (while transmission capacity may need to be expanded).

Bulgaria occasionally has been importing about 800 MW of capacity from the Ukraine during periods of peak demand, with about 4 - 5 TWh of electricity being imported yearly.

Trade with Romania remains limited given this country's economic and power sector problems and power exchanges with Yugoslavia has been stopped by the current international embargo. Bulgaria is currently negotiating with Greece and Turkey for enhancing their cross-boarder interconnections, expanding exchanges of power, and possible synchronization. Preliminary indications are that Greece and Macedonia could be potential power markets, if Bulgaria is able to develop capacity at a competitive price in the Balkan market.

### f) Power Project Prioritization

The procedure for evaluating power project investments should utilize a rigorous Integrated Resource Planning (IRP) process. In this manner, the most appropriate and least cost options will be developed. A key determinant for project selection will be how the power plant meets the load profile in terms of supplying peaking, intermediate, or base load capacity. The installed capacity ($/kW) and life cycle power costs ($/kWh) for each power project opportunity will also be essential factors in project selection. A summary of the installed capacity and life cycle costs of different power technologies based on the US and international market is found in Table 8.

Given the installed and generation costs of different technologies, it is likely that the first investment to consider will be demand side management options under $300/kW, then possible cogeneration and thermal plant repowerings in the range of $200/kW to $400/kW. For new generation options, hydro may provide economic generation at particular sites identified by Energoproekt. While hydro in the US ranges from between $2,000 to $3,000/kW, the high head sites in Bulgaria could reduce capital costs significantly. The choice of the optimal technologies and fuels will become clear after the IRP process has been implemented.



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| GENERATION SUPPLY OPTIONS<br>ESTIMATES OF INSTALLED AND LEVELIZED COSTS | | |
|---|---|---|
| | RANGE $/KW | TOTAL LEVELIZED COST ¢/KWH |
| Combustion Turbine | 275 - 500 | 11-16 |
| Diesel Generator | 375 - 1,005 | 9-26 |
| Combined Cycle | 500 - 800 | 5-6 |
| Pulverized Coal w/ Flue Gas Desulferization | 1,420 - 2,410 | 6-9 |
| Atmospheric Fluidized Bed Combustion | 1,600 - 2,600 | 6-8 |
| Wood Fired Steam | 2,700 | 7-8 |
| Conventional Hydro | 1,945 - 3,300 | N/A |

Source: Central Maine Power, Stone & Webster, and Electric Power Research Institute, 1993

Table 8

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## IV. EXISTING POLICY, REGULATORY AND INSTITUTIONAL CONDITIONS AFFECTING INDEPENDENT POWER DEVELOPMENT IN BULGARIA

### 1) Overview of the Existing Policy and Regulatory Framework

The existing statutory framework in Bulgaria is undergoing major changes. Only one statute, the Law on the Environment, has any significant implementing regulations. The prospects for a broad independent power program will be enhanced as the Bulgaria's laws and regulations become more developed. Nevertheless, a preliminary assessment of the power sector institutions and the energy bill currently being drafted indicates that a favorable policy and institutional framework is under development.

While it is important for the long term development of an active private power market in Bulgaria that the legislative and regulatory framework evolve from the current transitional phase to a more stable system, that evolution can be aided and even accelerated by the parallel development of specific projects. At this early stage, if NEK were to implement an informal developer selection process involving negotiations with about 3 or 4 different companies, it could ensure that these first projects are relatively competitive. By proceeding with one or more IPPs, actual experience is gained that will contribute to improving the policy and institutional framework. This issue is discussed in the conclusions to this section and the recommendations in Chapter V.

An overview of the principal Constitutional provisions and statutes affecting private power development is provided below with comments on what changes might improve the overall policy and legal framework.

#### a) Relevant Constitutional Provisions

**i) Private Property** Article 17 provides that the right to property shall be guaranteed by law and that private property shall be inviolable. Expropriation can be done only after fair compensation is assured in advance. A bilateral investment treaty with the US signed in September, 1992 should provide additional assurance to US investors.

**ii) Energy Sector** Article 18 identifies the activities which are to remain as Governmental monopolies. Water resources, mineral resources and parks, for example, continue to be under the exclusive control of the national government. With the exception of the use of nuclear energy, the energy sector is not so identified.

**iii) Environmental Protection** Article 15 states that Bulgaria shall ensure the protection of the environment and the conservation and sensible utilization of the country's natural and other resources. In addition, Article 5 provides that international instruments ratified by and in force with respect to Bulgaria have the effect of domestic legislation, and



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they supersede any domestic legislation stipulating otherwise. Bulgaria is a party to a number of international agreements on environmental issues, as discussed in Section IV(1)(b)(ii) below.

**iv) Site Acquisition** Article 21 of the Constitution restricts the use of arable land to agricultural purposes, absent exceptional circumstances and need, and Article 22 prohibits foreign individuals and entities from owning land in Bulgaria (but Bulgarian companies with up to 100% foreign ownership apparently can own non-agricultural land; see Section IV(1)(b)(iii) below). Leasehold interests and ownership of structures by foreign individuals and entities are not prohibited.

**b) Relevant Legislation**

**i) The Law on Electrical Energy (currently in discussion draft)**

This Law would require the "State Body on Energy," referred to in this report by its current name, the Committee of Energy or COE, to oversee the generation, transmission, distribution and use of electrical energy by the NEK. The Law contemplates that the COE will be charged with the protection of consumers and of the public interest, including determinations of need and of the cost effectiveness of generation expansion plans. Regulation of prices to consumers, however, is proposed to be made by a "Commission on State Energy Regulation" made up of representatives of several Ministries and other entities with an interest in energy prices. The "Inter-institutional Commission on State Energy Regulation," a temporary commission which would be responsible for the fairness of retail prices pending enactment of the law, is being authorized as of the date of this report. These entities are described in greater detail in Section IV(2)(a) below.

The current version of the draft Law indicates that a favorable policy framework in terms of power purchase pricing and terms will be offered to independent power generators to fill future needs for additional capacity. It requires the COE to create conditions to enhance competition in the generation of electric power and to create preferential conditions for the production of power by IPPs. The law contemplates a certification process for IPPs, in which applicants will be required to demonstrate that:

(1) they are compatible with the approved long term plan for production and transmission of energy;
(2) they have coordinated their planning with the local authorities, the Ministry of Environment (MOE) and the National Council on Water (NCW);
(3) their pricing is in the interest of consumers; and
(4) the public has been informed (detailed requirements for public involvement in the environmental review process, described in subsection (ii) below, will presumably satisfy this criterion).



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Clearly, the manner in which these requirements are applied will have an important effect on the commercial environment for private power in Bulgaria.

Given the short history of the institutions which would be involved with the implementation of this statute and the evolving and dynamic nature of regulation in this sector in countries throughout the world, it is reasonable to expect that international sources of capital will be concerned about arbitrary or capricious administration of the Law's policies. A number of the recommendations in Chapter V of this report are intended to address these concerns.

While the current draft does not distinguish between small power producers, cogenerators and other independently-owned generators, if so desired, such a distinction can be made in either the implementing regulations under the Law or in the Law itself. A number of jurisdictions, including the United States, has incorporated such a provision in its legislation. Such a distinction would encourage small independent power production through standard offers that conform to least cost planning principles but establish a standard avoided cost rate and simplify the contracting process for projects under 100 MW. [See Chapter V, Recommendation 9]

### ii) The Environmental Protection Act

The Environmental Protection Act was passed in 1991 and amended in 1992. It is a comprehensive environmental statute of broad applicability which establishes the rights of the citizens to a clean environment, to information on issues affecting the environment (Article 9), and to environmental impact assessments prior to construction, reconstruction or expansion of a wide range of projects, including power projects (Article 20).

As discussed in greater detail below, the Law affords the Ministry of the Environment (MOE) substantial authority to achieve its goals. No construction can be started until the MOE has approved the form and substance of the associated environmental impact assessment. Article 28(2) provides that the Minister of the Environment may suspend the regulations of other Ministries and Municipalities when they contravene the prescriptions of the Law, and Article 28(1) authorizes the Minister or the Regional Environmental Inspectorates to suspend or stop industrial activities which impact assessment established as damaging or threatening damage to the environment.

**Point Source Emissions -- Air:** Bulgaria has adopted emission standards for stationary sources. The standards for power generating facilities are not technology-specific, but rather are based on size categories (in MW) and fuel type. The Law requires sources to pay user charges in proportion to their emissions at or below the published standards for the emitting facility. Emissions exceeding the standards are subject to penalties in amounts up to 30 million Leva (approximately $1.2 million) per month.



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**Ambient Standards -- Air:** In addition to source emissions standards, Bulgaria has stringent ambient air quality standards modeled on those of Germany. They stipulate maximum allowable concentrations, over 30 minute and 24 hour averaging periods, for 171 categories of pollutants. The standard for particulates is comparable to that of the US, but the standards for SO2 and CO are almost an order of magnitude more stringent. Bulgaria is a signatory to the Helsinki Protocol on SO2 and a Sofia Protocol on NOx, and the Vienna convention and the Montreal Protocol on protection of the ozone layer. It is, for example, required by the Helsinki Protocol to reduce its SO2 emissions by 30% from 1980 levels by the end of 1993. Bulgaria's ambient standards govern a wide range of pollution in addition to air quality, including noise and odor pollution. MOE, however, has not yet established a permit system for air pollution discharges.

Because the ambient air quality standards are generally perceived as unrealistic, and given the current state of the economy, there is now little or no effort to enforce them. However, in addition to the penalties described above, there is authority for the assessment of civil penalties against individuals for the violation of environmental laws and regulations (Article 32). Moreover, Article 29 of the statute requires a polluter to remedy any damage it causes with compensation at least equal to the cost of repair. Article 353bis of the Penal Code, which provides that persons who conceal or falsify information resulting in material damage to the environment or to human health will be liable to fine and imprisonment for up to five years, applies only to government officials.

**Ambient Standards and Point Source Emissions -- Water:** Ambient water quality standards have also been established for three classes of receiving waters, Class I for drinking water quality, Class II for recreation and fishing, and Class III for irrigation. Direct discharges to surface waters must meet the Class II standards. The MOE is currently putting in place a permitting system for discharges to waters. There are also two standards for the discharge of waste to sewerage systems, depending on whether they are served by treatment facilities.

**Environmental Impact Assessment:** While most existing sources have not yet felt the impact of the Environmental Protection Act and associated regulations, the MOE has established a detailed environmental impact assessment procedure, called an Evaluation of the Effect on the Environment ("EEE") study, pursuant to Article 20 of the Environmental Protection Act. It will serve for all practical purposes as a comprehensive permit review procedure. Most importantly, it gives the MOE great discretion and final authority over the approval of new power generation facilities. It requires the evaluation of the effect of a broad spectrum of activities (including the construction, expansion, reconstruction and conversion of power generation facilities) on air, water, land, flora, fauna, "protected areas," landscape, people, residential settlements and cultural heritage.

Thermal power stations with 300 MW or greater capacity are under the exclusive jurisdiction of the MOE. Other "industrial" electrical generation facilities, hydroelectric facilities and overhead transmission lines are under the MOE's jurisdiction if their impact extends beyond the Regional Environmental Inspectorate in which they are located, if they

discharge more than 30 liters per second of waste water, if they burn more than 750 kg of waste (averaging period not specified), or if the value of the project exceeds 50 million Leva ($2 million). Otherwise, they are under the jurisdiction of the Regional Environmental Inspectorate. Article 20 requires that assessments of "large" polluting facilities must be made at least once every five years.

EEEs must be prepared by experts, who must certify that they are professionally competent and that they have no direct interest in the facility and have not participated in its design. Article 23 requires that the MOE, or the Regional Environmental Inspectorate if it has jurisdiction, review the EEE and organize a public meeting on at least one month's notice to interested parties. It will issue its decision within three months of the hearing. Appeals may be lodged within 14 days, or within 30 days for projects of national significance. The statute requires the reviewing authority to prohibit the implementation of projects for which the assessment is not complete or is negative, or which are not equipped with the necessary pollution control equipment. Finally and importantly, the statute provides that the state is responsible for the cost of remediation of pre-existing pollution at industrial sites.

It should be noted that this Law does not supersede the many other environment-related statutes, dating back to the 1950's, which remain on the books. It has been estimated that over 120 of such laws are in force, including seven of potentially direct relevance to independent power development. However, the relationship of the new statute to the old statutes is not yet clear. In addition, other new environmental statutes dealing specifically with air, water and soil pollution are now being prepared. It is expected that they will expressly supersede some, but not all, of the prior legislation. Regulations dealing with environmental audits of existing facilities are also being prepared.

### iii) Property and Resource Rights Legislation

**Law on the Ownership and the Use of Agricultural Lands:** Articles 31 and 33 of this Law establish the Ministry of Agriculture and the Municipal Land Commissions as the jurisdictional authorities over land ownership issues. This law's primary thrust is the restitution of farmland to those owning it prior to collectivization, or to their heirs. It also prohibits the ownership of (but not the lease of) arable land by foreign individuals, foreign companies and domestic entities with more than 50% foreign ownership. However, the use of arable land for other than agricultural purposes is strongly discouraged by both the statute and the Constitution (Article 221bis of the Penal Code provides for fines and up to three to five years' imprisonment for persons, presumably but not explicitly government officials, permitting non-agricultural uses of agricultural land). Therefore, the development of new power facilities on land which is classified as arable is unlikely. However, the definition of arable land in Article 2 of the law specifically excludes land within community boundaries, forest domains (which should be distinguished from agricultural land which has been reforested), and land on which industrial, commercial, and energy facilities and their yards and ancillary facilities have been built.



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There is an expectation that the Parliament will soon consider the enactment of similar legislation for the restitution of expropriated forest land. Although forest land is not afforded the same constitutional status as arable land, use for industrial or commercial purposes is strongly discouraged.

In the past decades, many of the industrial facilities now being privatized were sited on agricultural land. Apparently they are now properly classified, along with the underlying real property, as state assets under the Law on Conversion and Privatization of State Owned Enterprises. The definitional provisions of the two statutes, however, leave some ambiguity on this issue. The boundaries between the industrial and agricultural properties also are likely to be subject to some dispute.

Several other laws for the purpose of restitution have also been enacted: for nationalized immovable property; certain nationalized property; and certain shops, workshops, warehouses and pharmacies. There are other laws, such as the 1951 Law on Contracts and Obligations, which have potential relevance to site acquisition. An exhaustive review of such laws is beyond the scope of this report, and in any event this law and many others are expected to be repealed if and when a new law on the same subject is passed by the Parliament.

### iv) Privatization and Investment Legislation

**Foreign Persons' Business Activity and Foreign Investment Protection Act:** This law provides foreign individuals and foreign domiciled entities the right to do business in Bulgaria on equal terms with Bulgarian entities. Article 7 further provides that foreign persons are entitled to most-favored-nation treatment if an international agreement so provides (the U.S Trade Agreement became effective in 1991 and includes a most-favored-nation clause).

Foreign individuals and entities can freely open bank accounts, deal in securities, convert leva into dollars and repatriate both income and capital. Under Article 5 they can own improvements to real property and they can lease land, but neither foreign persons nor domestic entities with majority foreign ownership can own agricultural land. There is no apparent restriction on the percentage of foreign ownership in a Bulgarian company owning non-arable land. A 100% foreign-owned company with Bulgarian domicile should therefore be able to own industrial assets, including the real property.

Article 12 provides that claims can be secured by pledge or by mortgage, although Article 11 also requires foreigners to register their investments assets, and changes thereto, with the Ministry of Finance.

The provisions of this Law also govern labor and social insurance issues. They stipulate that an employment contract will provide the basis for the relationship between employer and employee, and, to the extent issues are not covered in the contract, the Bulgarian legislation



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shall govern. However, certain basic contractual issues (hours, minimum wage, termination notice and payment, occupational hazard protection) must conform to Bulgarian Law.

**Law on Transformation and Privatization of State-Owned and Municipal Enterprises:** The scope of this law is the privatization of industrial, commercial, construction and transportation companies. It therefore is relevant mainly to IPP participation in industrial cogeneration. It may also be relevant to investments in refurbishing utility-owned plant. It provides for privatization through the sale of state enterprises, either before or after their conversion into commercial companies.

Large state-owned (as distinguished from municipally-owned) companies whose book value of fixed assets is over 10 million Leva will be privatized by the Privatization Agency, with the approval of the Council of Ministers in the case of book fixed assets over 200 million Leva. Companies with a book value of fixed assets at or below 10 million Leva are privatized through the relevant ministry. These smaller companies can also be acquired through lease-purchase arrangements, management contracts with purchase options, installment sales and conditional sales. Municipal companies of any size will be privatized by the Municipality in question.

Decree No. 105 of the Council of Ministers regulates the process for enterprises which are put up for auction, and foreign persons may participate freely in auctions subject to the restrictions on ownership of land.

In principle, it should not be difficult for investors in, and lenders to, independent power projects to obtain clear title to project assets, even those subject to claims of restitution, as sales of property under this statute will in most cases be without encumbrance. However, it appears that Article 18 provides claimants a preemptive right to shares in enterprises built on expropriated or collectivized land, in some cases limited to two months after the promulgation of the privatization decision. A transitional provision also makes voidable a "disposal transaction" of state or municipal property under "apparently unfavorable conditions" after 1989. Land ownership and lien records are addressed in Section IV(2)(e) below.

The first of three parts of a **Commercial Code** has also been enacted by the Parliament. It defines the permissible organizational forms for transacting business in Bulgaria and the associated obligations, rights and procedures. It is generally consistent with western European practice.

### v) Conclusions on the Policy and Regulatory Framework

Bulgaria has made a positive effort to establish a favorable legal framework for attracting international capital. The passage of the Law on Electrical Energy will be another important step in that direction. Whether the preference for IPPs contained in the draft Law will attract a broad spectrum of potential investors and thereby create long-term active competition in the power generation sector will depend on several additional factors. These



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factors are also relevant, but of less concern, to project sponsors negotiating specific projects in parallel with the efforts recommended below.

The content of the implementing regulations will be an important factor. If those regulations provide prospective independent power investors with an expectation of equitable treatment and reasonable certainty of a rational selection process, one important leg of the policy and regulatory framework for IPP development will be in place. See the Conclusions to the following Section on institutional issues, and Recommendation 3.

A final recommendation concerns the consolidation of the project review process. In light of the uncertainties surrounding existing statutes and their administration, it would be helpful to consolidate the authority for project approval as much as possible. The Certific of Need does not incorporate the considerations of other concerned agencies It would helpful if the COE's statutory authority were expanded to enable it to be e a centr clearing house for all or most of the permits required, as described in Recommendation 1 Chapter V.

Most important, it will depend on investors' confidence in a rational and consistent legal and regulatory system. Bulgaria's economy is in a transitional phase, and so are its legislation, regulations and policies. The direction of the policies has become clear, but the legislative basis for implementing those policies is still in a formative stage. A great deal of pre-1989 legislation remains in force, including some which is still relevant to concerns of potential investors. Examples include the 1951 Law on Contracts and Obligations and a series of environmental laws on water, air and land pollution. How those laws relate to recent legislation will require clarification. As noted in the text of this section, a number of the new laws also contain provisions which are also likely to concern potential investors.

The Parliament is currently working on legislation to replace the earlier statutes, and much other new legislation is also in preparation. These efforts are still in a relatively early stage, so it cannot be concluded that a rational and consistent system of laws and regulations is yet in place. The associated uncertainties will make it difficult to attract international capital to the broad power sector in the near term. However, every effort should be made to promptly incorporate the newly enacted statutes and the prior legislation into a consistent framework. [See Recommendation 1 of Chapter V]

To attract international capital there should also be an established and reliable system of legal recourse. A detailed evaluation of the Bulgarian legal system is beyond the scope of this report. However, as with the economy and the legislation, the judicial system in Bulgaria is in transition from serving as an arm of the state to acting as an independent judiciary. It will therefore probably be necessary for all parties to an independent power contract to submit to binding dispute resolution by an independent third party in a neutral jurisdiction, possibly outside of Bulgaria. Such a Provision should be included in the contract forms suggested under Recommendations 9 and 10 of Chapter V.



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## 2) The Existing Institutional Structure

### a) Committee of Energy, NEK, and Energoproekt

**The COE** is appointed by and reports directly to the Council of Ministers. The Parliament also has a **Commission on Energy and Energy Resources,** a 13 member body which provides legislative oversight of the COE and the energy sector generally. The COE is the governmental department charged, among other things, with general oversight of utility operations and encouragement of the independent power sector. In addition to responsibility for the generation, transmission, distribution and use of electric power it is responsible for oversight of the coal industry and the district heating sector, although some of the latter facilities are expected to be transferred to Municipal control. Its functions do not include mineral exploration or oil and gas exploration or production, which are under the jurisdiction of the Ministry of Geology, nor oversight of the petroleum, natural gas or petrochemical sectors, which are under the Ministry of Industry.

A recent organization chart showing the responsibilities and functions of the COE and other agencies with involvement in the energy sector is found in Figure 5. The World Bank recommended, in their April 30, 1992 study of the energy sector, that other energy-related organizations operating under the jurisdiction of the Ministry of Industry and the Committee of Geology (see below), be consolidated under the jurisdiction of a single energy agency. It also recommended that the district heating companies be subjected, along with NEK and Bulgargaz, to the regulatory authority of a newly created energy regulatory authority.

The general functions contemplated for the COE were described in the section "Relevant Legislation -- The Law on Electrical Energy." Specifically, the draft statute provides that the COE will be charged, among other things, with assuring that the electrical energy needs of the nation are met, with stimulating efficiency and economy in the sector, with creating conditions for competition in the production and distribution of power, with creating preferential conditions for IPP supply, and for protecting the interests of consumers, citizens, and the environment.

The draft Law also contemplates the creation of a "Commission on State Energy Regulation" which will be delegated certain of the COE's responsibilities to protect consumer interests. That nine-member commission would consist of three members from the COE (with one serving as Chairman), the Ministers of Finance, Industry, Transportation, Commerce and Social Welfare, along with a representative of the Council of Consumers. Pending passage of the legislation creating this commission, the Council of Ministers recently decided to establish a temporary group called the **Inter-Institutional Commission on State Energy Regulation.** This four-person organization, comprised of the Deputy Ministers of Finance, Industry, Social Welfare and Prices, are delegated the COE's responsibility to protect consumers' interests with regard to the price and reliability of electric energy.



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NEK, The Natsionalna Elektricheska Kompania, currently owns over 85% of Bulgaria's electric generating resources and essentially all of its transmission and distribution facilities. Its distribution system serves NEK's consumers through 28 branch organizations. NEK was formed as a joint-stock company in 1991. Its shareholders (currently the sole shareholder is the State, with voting power exercised by the Council of Ministers) elect a Chairman and six members to the Company's Supervisory Board. The Supervisory Board then appoints the six-member Managing Board, including the Company's President and Vice President.

NEK is now, and will be, the purchaser of all power sold to the grid by independents. It has negotiated parallel generation agreements with ten cogenerators and nine district heating plants, aggregating approximately 1000 MW of currently available capacity (a number of small hydroelectric facilities have also signed contracts with the utility, but they do not have consistent provisions). The agreement is a standard form of contract effective for one year. Prices currently paid to the independent suppliers are negotiated within a narrow band equal to NEK's own industrial tariff rate, less 15% to 18% for unavoidable administration costs and losses. A twenty percent premium is due to independent generators when they generate power at the request of NEK and would not otherwise be generating thermal energy for their own needs.

The NEK standard power purchase agreement (as found in the Appendix) contains many terms familiar to independent power developers in the US The provisions of Article 12, which requires payment by the utility on the day following receipt of the invoice, is less familiar. Other provisions commonly required by IPPs and utilities in the US and international market are not included, for several reasons.

**First**, the complexities associated with mobilizing international capital have been addressed in an earlier section. They obviously have not been relevant to NEK's negotiations with Bulgarian cogenerators to date.

**Second**, the price structure of the energy sector has historically provided no incentive to the Bulgarian industrial and district heating cogenerators to generate excess energy, and any such energy has been a necessary byproduct of each facility's own energy needs (see, for example, PPA Article 5). NEK should include more stringent dispatch and equivalent availability requirements in future cogeneration contracts.

**Third**, capital investment at cogeneration plants has been made independent of external power sales considerations, and the retail tariffs (and therefore the buyback rates) of the utility have been set without regard to capital recovery. This has resulted in negotiations based on variable cost-based pricing, adjusted annually to reflect changes in such costs. The determination of the utility's long-run marginal cost, including a capital recovery component, will provide a more realistic price signal to prospective sellers. Those sellers will also require more certainty of capital recovery than can be realized by annual renegotiations, with the associated potential for reductions in capital recovery factors. Independent generators will therefore require contracts with a fixed price component (normally the capacity portion of a



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two-part tariff) for a term at least sufficient to retire debt obligations associated with the project.

In developing a new model agreement the utility may require much more detailed information about the design, financing, construction, and operation of an IPP than has been the case in the past. In addition it may require development and operational security deposits from the developer. It should establish clear performance milestones and dispatch, operating reliability, and availability targets which are tailored to the characteristics of the IPP and the needs of the utility. A system of penalties for deficient performance and bonuses for superior performance may also be considered. While the temperature- and part-load-dependent operating characteristics of the IPP's technology are not of direct concern to the utility, dispatch and variable pricing provisions should reflect operating reality. Likewise, capacity and reliability testing and evaluation should be done on a consistent basis for utility plants and IPPs.

One of the most difficult issues to incorporate into the IPP contract in any context is excuse of performance for force majeure, and particularly excuse for fuel interruptions. Again, the IPP should be required to perform with the same assurance of reliability as the utility would reasonably expect from its own units, if similarly situated. One of the primary advantages to a utility of contracting for independent power is the shifting of construction and (usually, non-fuel) operating risk to the IPP. The associated risks are readily controlled by the IPP, so the cost to the utility of that service should be quite small and outweighed by the benefits. It is not recommended, however, to allocate risks to IPPs which are beyond their control or beyond their expertise. The IPPs will then price the risk conservatively, either increasing the real price of power to the utility or leaving the market, leaving the risk with the utility in any event.

While US and international contracts are normally much more complex in structure than the current NEK form of agreement, in most fundamental respects the two are similar. With the above-noted elaborations to define the additional obligations and assumptions of both project as well as certain aspects of political risks by the parties, the NEK form should be readily adapted to future use. [See Chapter V, Recommendation 10]

Energoproekt, established in 1948, has acted as the planning, research, engineering and design group for the COE and NEK. It is in effect a fully integrated design and engineering firm organized into 7 divisions, including hydropower, thermal power, transmission and distribution, nuclear energy, automation, research, and engineering investigations. It has extensive domestic and international experience, having involvement with the design, construction or execution of over 100 major projects around the world.



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### b) Ministry of Industry

The Ministry of Industry has responsibility for a substantial number of energy-related sectors. The organizational chart found as Figure 6 illustrates the organization of the Ministry. It has Neftochim, which operates a large refinery at Bourgas, and two smaller refineries under its jurisdiction. It also controls petroleum products distribution and transportation fuel marketing through Petrol, and controls natural gas transportation through Bulgargaz, the state pipeline company. Finally, it controls the marketing of household fuels (briquettes, LPG and coal) through Toplivo. Mineral, oil and gas exploration is under the jurisdiction of yet another energy-related organization, the Committee of Geology. The Ministry of Industry has authority over a number of facilities which have a significant thermal load and might prove to have economic cogeneration potential, including the Bourgas petrochemical facility, the Kremikovtzi steel facility, and the Chimco Vratsa fertilizer plant.

### c) Ministry of the Environment

The Ministry of the Environment (MOE) has a broad Constitutional and statutory mandate to establish a clean and healthy environment in Bulgaria. As described earlier, it also has a great deal of discretion under the Law on the Environment in the review of proposed construction or modifications. It maintains headquarters and a research center in Sofia and is organized into six departments, including water, air and soil protection. The Monitoring, Research and Information Center collects and publishes ambient data from its monitoring activities and other sources (the Ministry of Health and the Institute of Hydrology and Meteorology also collect environmental data) in a quarterly bulletin. The MOE is divided for administrative purposes into sixteen regions, called "Regional Environmental Inspectorates," which are responsible for surveillance and enforcement of the Law on the Environment. The regional division boundaries are not coterminous with the administrative Districts described in Section (e) below.

Ambient air data is collected at over 100 sampling locations, 60 of which are operated by the MOE, and almost all of which are located adjacent to urban and industrial complexes. In addition, the MOE has a mobile monitoring lab. Historical data are of questionable value due to irregular or inconsistent sampling and testing procedures. However, the European Community's PHARE program is providing substantial funding for new equipment and training programs and data quality is expected to improve accordingly. However, it will remain difficult to integrate information collected by the various agencies as the nine administrative oblasts, the 16 Regional Environmental Inspectorates and the 28 districts used by the Ministry of Health all have different boundaries.

Water quality data are collected for surface waters at approximately 200 sampling points and at 276 groundwater monitoring points. A hydrogeology yearbook is published by the MOE. The MOE also periodically monitors point source discharges.



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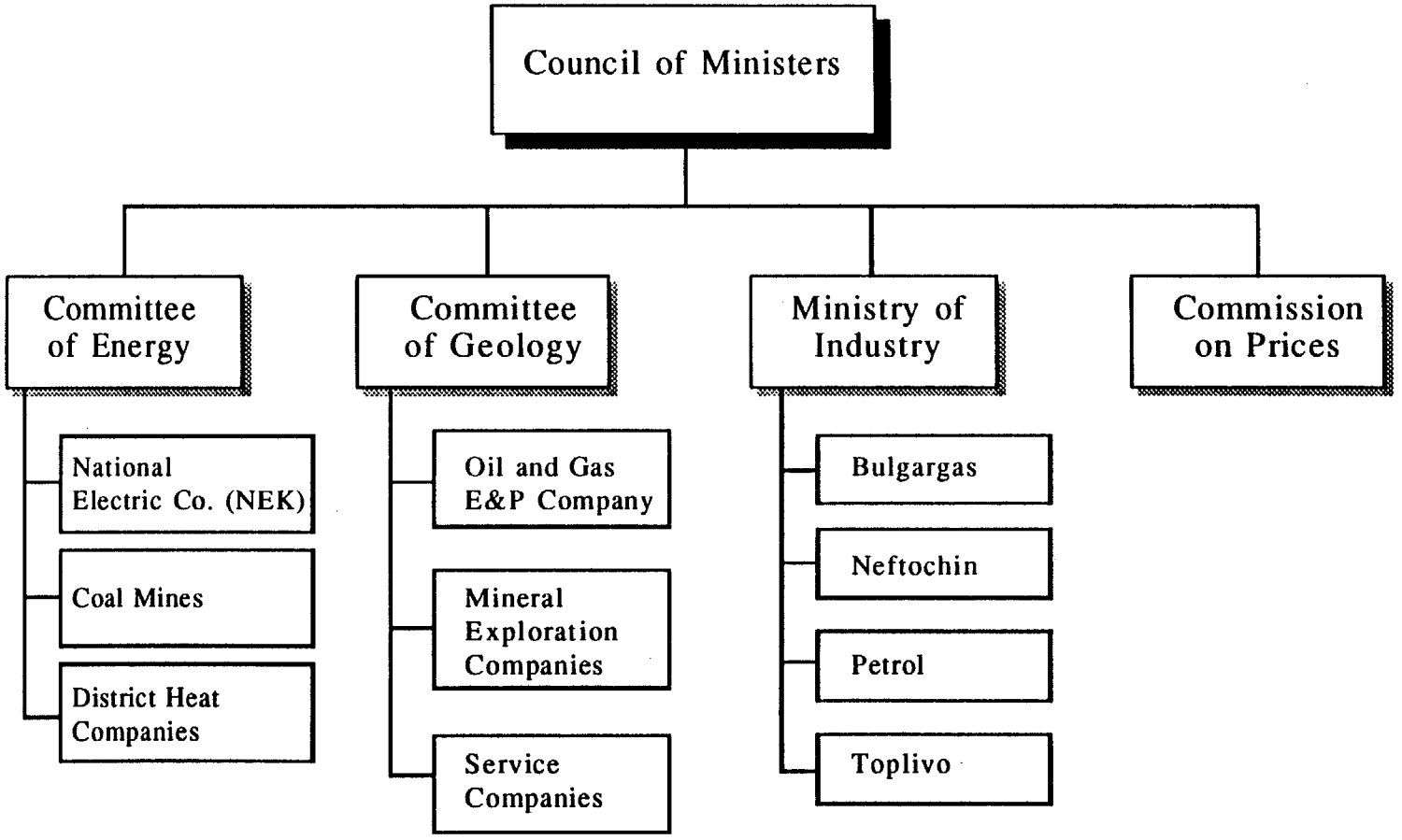
# Bulgaria: Current Organization of the Energy Sector




Source: World Bank, 1992

Figure 6

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The process for obtaining environmental approvals was discussed earlier in this report, as were the EEE regulations stipulating the lead jurisdiction for review of environmental impact. Whether it is the headquarters or the Regional Inspectorate, prospective investors should expect significant delays in review due to the enormous responsibilities which are assigned to the MOE staff and the limited resources available to them.

Upon approval of the EEE, application for a construction permit can be made to The Ministry of Construction and Regional Development, which has overall responsibility for building codes and authorizations. For smaller projects of primarily local concern, MOE will likely delegate its authority to the Municipality concerned. For projects of national significance, review and approval will be coordinated from Sofia.

It was noted in the prior section that in addition to the Law on the Environment there are more than 120 older statutes regulating environmental matters, including seven which may be of direct relevance to a proposed power project. While they do not have the strong enforcement provisions of the new law, they technically remain in effect and should be reviewed by prospective investors.

**d) National Council on Water**

The primary role of the National Council on Water (NCW), which has 12 members representing the large water users of the nation, currently is the preparation of monthly water allocation plans for water resources from 22 multiple purpose dams in Bulgaria. The COE, which controls the impoundments, is responsible for implementation of the plan. The priority of use is as follows: human consumption, livestock consumption, industrial needs, agricultural needs, and power generation. There are recent instances of shortages even for human consumption purposes, and, in fact, in early summer 1993 reservoir levels are critically low.

The issuance of a Certificate of Need by the COE will be conditioned on coordination with the NCW. The siting and design of new thermal plants will certainly have to take into account the occasional scarcity of water for power generation uses. It is unlikely that the NCW would have any objection to a run-of-river hydroelectric facility, or to an impoundment for which the operation would not interfere with downstream allocations. On the other hand, subordination of operation of a new project to the NCW's priorities might well reduce the value of the facility for power generation purposes.

**e) Local District and Municipal Governments**

Bulgaria is divided into approximately 250 Municipalities, or "Obshtina," each of which has a popularly elected Municipal Council and Mayor. The Municipal Council in turn appoints an administrative staff to perform executive functions for the Municipality. Each Municipality has a property office which maintains records of land divisions and ownership



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initially had a bias in favor of building their own plants. Over time they developed an appreciation for role of independent generation. The extent to which the independent power industry develops in Bulgaria will depend on whether NEK sees it in its own interest to encourage this competitive generation market. It is recommended that NEK develop an institutional policy in favor of independent power and specific goals be set for NEK and its negotiating team against which specific progress can be measured. [See Recommendations 6 and 7 of Chapter V]

The use of integrated resource planning techniques to establish pricing and to evaluate proposals will also demonstrate NEK's commitment to a rational and equitable selection process. [See Recommendation 5 of Chapter V]. Further comfort would come from the development of a model contract for large projects addressing the principal non-price terms of concern to investors. [See Chapter V, Recommendation 10; this issue, and the related issues addressed in recommendations 6 and 8, are the most critical for sponsors of specific projects prior to the establishment of a stable and favorable regulatory framework.]

Long term success will also depend on the attitude and authority of the COE. It is ultimately the regulatory authority which must define the policies of the utility sector, and then encourage or enforce compliance with those policies. The development of detailed regulations by or under the supervision of the COE will be an essential element in defining the policies, but the application of those regulations will be crucial to the confidence of the international markets.

To that end, the staff of the regulatory body should be selected and trained to provide full understanding of all issues which may affect utility policy or influence the analysis and decisions of the NEK negotiating team. [See Chapter V, Recommendation 2] Similarly, the NEK negotiating team should be selected and trained to assure their familiarity with the principles and practices of utility operations and power contract negotiations. [See Chapter V, Recommendation 8]

Lastly, the attitudes and capabilities of other governmental institutions will be important. The MOE, in particular, will undoubtedly play an active role in the review of power plant projects. The control of environmental impacts from power plants is a complex and technical matter and is likely to strain the limited resources of that staff. It is in the interest of all concerned to include representatives of other agencies in educational processes which will increase their understanding of the potential and the limitations of power plant emissions controls. Close cooperation between different government agencies on the various permitting requirements for power projects (e.g. environmental, water rights, land use, etc.) will greatly facilitate the process of developing a commercial independent power market.



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within its boundaries. However, recordation of mortgages is accomplished at Notarial registries which are maintained in conjunction with, and are located at, the local court for the jurisdiction. While investigations of ownership records should be relatively straightforward in most Municipalities, mortgage records are sometimes incomplete and often not maintained in any systematic fashion.

The Municipal Council has jurisdiction over matters of local interest other than those relating to the restitution of agricultural land. It collects local taxes. It also has the authority to issue bonds. Municipalities are responsible for providing local utility services such as water, waste water and solid waste disposal. They can aggregate themselves to form a special purpose district, or "okolija," which can provide inter-Municipal services such as water supply, waste water disposal, or public transport.

Restitution of agricultural land is under the local jurisdiction of the Municipal Land Commission (MLC), the members and Chairman of which are appointed in each Municipality by the Minister of Agriculture. Each MLC is required by the Law on the Ownership and the Use of Agricultural Lands to maintain a register for all applications for restitution and for all decisions rendered by the MLC.

The Municipalities outside Sofia are aggregated into eight regions, or "Oblasts," which serve as administrative units of the national government. The Governor of the Oblast is appointed by the Council of Ministers for a four year term. The Municipalities comprising Sofia are considered a special region and have a popularly elected Mayor, rather than an appointed Governor.

As noted earlier, the Municipalities may soon be the owners of the district heating plants, They would then be responsible for management or privatization of those assets. The transfer of the district heating plants to the Municipalities is under active debate in Parliament, since most Municipalities are ill-equipped to manage them.

### f) Conclusions to the Institutional Structure Evaluation

As noted in the conclusions to the previous section, Bulgaria has taken a number of positive steps in establishing the necessary IPP policy and institutional framework, as found in the leadership being taken by COE and NEK and the draft Law on Electrical Energy. The passage of the Law on Electrical Energy by the Parliament will be an important step in developing an IPP market, particularly with regards to the establishment of an independent regulatory body, but the effectiveness of the draft Law in creating an active long term market will depend on the policy and regulatory factors already cited. IPP developers negotiating specific projects will be equally concerned with institutional attitudes and competence.

The success of independent power will depend to a large extent on the attitudes of the institutions involved. In the US independent power industry development experience, utilities



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## V. SUGGESTED APPROACHES FOR THE INTRODUCTION OF A POLICY AND INSTITUTIONAL FRAMEWORK TO PROMOTE INDEPENDENT POWER AND PRIVATE INVESTMENT

Bulgaria is currently evolving from a centrally-planned economy to a market economy with a democratic government. The vast majority of relevant statutes and regulations are either newly created or do not yet exist. Even for those which do exist, the institutions which will administer the statutes and regulations are either newly created or are assuming new responsibilities. There is no history, therefore, which prospective investors can evaluate in order to gain confidence in the impartiality of the decision-making process. As a result, it would be desirable to strengthen the policy and institutional framework according to the recommendations discussed below.

### 1) Strengthen Components of Legislation to Facilitate Independent Power

The current draft of the Law on Energy will, when enacted, establish a favorable policy for the development of independent power in Bulgaria. In particular, it establishes a policy of favorable conditions for independent power, authorizes the execution of long-term power purchase agreements by the utility and establishes relatively clear conditions for the issuance of Certificates of Need.

However, the current draft does not provide for any governmental agency to have authority to issue a final approval on behalf of the Government of Bulgaria. In the US, the state regulatory commission's issuance of a Certificate of Need (or the FERC's issuance of a hydroelectric license) typically signals the satisfaction of all governmental review requirements other than emissions permits and local construction permits. In Bulgaria, there may be Ministries and governmental organizations which have authority over one or more aspects of a proposed project but which are not easily identified by prospective investors. The consolidation of many project review functions through the Evaluation of the Effect on the Environment ("EEE") process is helpful, although that process does not result in a final, determinative authorization to proceed with the project from any organization other than The Ministry of the Environment. It is, therefore, recommended that the EEE determination be made binding on any agency consulted or notified during the EEE process. It is further recommended that one government agency have the responsibility both to identify and coordinate with all jurisdictional authorities not included in the EEE process, and to make a final determination that the governmental approval process is complete. This coordination could logically be accomplished by staff of the regulatory body with the issuance of the Certificate of Need, which would signal the final approval of the project.

Similarly, as noted in the body of this report, there are other statutes which have ambiguities which could inhibit development of an independent power sector in Bulgaria. The privatization law, for example, apparently provides to former landowners preemptive rights



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in state or municipal enterprises built on expropriated land, and makes voidable certain "disposal transactions," presumably sales, under "unfavorable conditions." Ambiguities also exist in other statutes, for example the Law on Ownership and Use of Agricultural Lands, which may make it difficult to assure clear title to prospective purchasers of formerly agricultural land. It is, therefore, recommended that a comprehensive review of all Bulgarian laws affecting the environment or property rights be undertaken, with the goal of identifying and clarifying any potential conflicts or inconsistencies.

### 2) Establish Power Sector Regulatory Institution and Ensure Staffing by Qualified Regulators

The absence of any history of utility regulation in Bulgaria makes it imperative that any such regulatory body be established both with clearly defined functions and authorities, with qualified staff and with resources adequate to fulfill their responsibilities. As the Bulgarian Government completes its deliberations over the regulatory model to be used, a study of necessary resources will need to be performed. Issues to be addressed at a minimum would be:

- Staffing and training of regulatory commission personnel in generation expansion planning and integrated resource planning;
- training of regulatory commission personnel in finance and accounting;
- hardware and software necessary to monitor and corroborate the integrated resource plans of the franchised utilities; and
- training of regulatory commission personnel in utility operational issues.

### 3) Develop and Publish Detailed Regulations

The evolving and dynamic nature of regulation in the power sector in countries worldwide, combined with the unaccustomed responsibilities of the entities implementing Bulgaria's utility regulatory systems, will give rise to concern by prospective investors about arbitrary or capricious administration of the regulatory policies. It is, therefore, important that the implementing regulations define with precision the requirements, for example, for timing and approval of generation expansion needs. It is recommended that the regulatory body consider requiring significant detail in utility IRP submittals while allowing NEK enough flexibility to optimize the process over time. Such details might include, in addition to the usual procedural guidelines, substantive technical requirements for type, format and availability of data, and modeling protocols, analyses and results.

The regulations will need to also set out detailed requirements for solicitations or proposals to supply additional capacity. These requirements should assure that capacity expansions and renovations are consistent with the Integrated Resource Plan and other policies of the Bulgarian government. Such regulations might prohibit the recovery of capital

investments made by NEK without authorization of the regulatory body and require the solicitation and analysis of alternative proposals prior to authorizing the utility to proceed with its own construction.

**4) Establish Central Information Clearinghouse for IPP Developers**

In order to counteract the unfamiliarity of many potential investors with Bulgaria and its institutions, it is recommended that the Committee of Energy (COE) or NEK assemble and make available information on the institutional framework, as well as technical data, such as hydrology at prospective hydroelectric sites or thermal demand at cogeneration facilities, which would be of interest to project developers.

COE or NEK would be advised to consider making the information on the utility's least-cost plan assumptions, modeling methodology and results available to prospective investors. Most importantly, this would allow project developers to optimize their project configurations to the needs of (and the benefit of) the utility system. It would also give investors added comfort that the technical and economic evaluation process is handled equitably.

Finally, it is recommended that an information package providing potential power developers with relevant details about conditions in Bulgaria be prepared and distributed on request and at industry conferences.

**5) Use Integrated Resource Planning (IRP) to Establish Long-Run Marginal and Avoided Cost pricing and Project Selection**

One goal of the IRP planning process should be to establish the power project costs from which project developers as well as utility planners can evaluate the cost-effectiveness of their proposals. It should be recognized that these cost figures will change over time based on the state of technology and market conditions. In the face of uncertainty, the fair estimation of such costs is an essential component of rational utility and IPP decision making. It is also necessary to provide independent suppliers with a fair price for their production while protecting the utility from paying windfall profits to those suppliers.

Proposed projects large enough to have an impact on system economics should be evaluated in the utility's model and compared to the utility's base case plan with respect to economics and reliability.

**6) Establish Consistent Policy Regarding Government Guarantees of Utility Performance**

Given the limited experience of NEK and other Bulgarian public and private entities in operating as financially sound and independent institutions, it is highly likely that a foreign



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investor and developer would require the Government of Bulgaria (GOB) to provide guarantees and other incentives. For instance, the GOB may need to guarantee that NEK will honor its commitments in the power purchase agreement with a developer. Should NEK, for whatever reason, not be able to pay the developer according to the terms of a signed power purchase agreement, the GOB would provide the financial resources necessary to honor the contract. Developers may also seek guarantees from the GOB regarding the performance of government-owned fuel suppliers and the National Bank of Bulgaria. Finally, it is likely that the GOB will be asked for support with respect to foreign exchange availability, force majeure, and other related issues.

Based on the requirements in the international independent power market, the GOB will need to develop a policy regarding what types of guarantees and incentives it is willing to provide. In the early phases of developing Bulgaria's independent power market, it may be necessary to provide substantial guarantees and assistance, but as the IPP market matures and the perceived risks diminish, it would be possible to reduce the type and scope of support offered.

### 7) Establish Policy for Soliciting Independent Power

NEK may chose to negotiate with the proponents of unsolicited proposals in the early phases of IPP market development in order to overcome the unfamiliarity of project sponsors with conditions in Bulgaria. In more mature market phases and when project precedents have been established, it may be desirable to move to a competitive bidding format. The advantage of competitive bidding is that it can result in lower electricity rates and more favorable terms for the utility and the consumer. Given the substantial costs of preparing an independent power proposal, however, competitive bidding can slow down the project selection process and discourage participation by developers.

### 8) Establish and Train a Multi-Disciplinary Review and Negotiations Team

In order to protect the purchasing utility's interest while allowing for expeditious selection of project proposals and resolution of unresolved contract issues with their sponsors, it is recommended that a multi-disciplinary review and negotiation team be established at NEK. The team should be comprised of engineers with experience in generation, transmission and distribution operations, fuel procurement, planning and central dispatch. It would also include lawyers specialized in Bulgarian administrative law and procedure. All members of the team would receive training in the principles of contract law and international and project finance.



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## 9) Provide Standard Offer Contracts for Small Renewable and Cogeneration Projects

The development of smaller projects can prove significant to Bulgaria by expanding the use of indigenous energy resources and renewable fuels. However, the transaction costs associated with extended negotiations of price and terms with a purchasing utility can be a major deterrent to potential investors. The elimination of this deterrent through establishment of a "Standard Offer" is recommended.

To implement this recommendation, it will be necessary to establish a class of favored generation technologies and a maximum size for each project which will permit economic development of the resource and the project without adversely affecting NEK's planning or operating characteristics. It will also be necessary to establish a purchase tariff (including terms and conditions) which is structured to assure reliable operation of the facility and pricing which fairly reflects avoided costs. Energy price indexing should be considered, as should capital cost indexing. The terms of the Standard Offer would be non-negotiable; nonetheless the project sponsor would create an effective long-term contract by merely signing and delivering the offer.

## 10) Provide Standard non-Price Terms for Large Projects

For larger projects it is not recommended to provide "Standard Offer" contracts. NEK will need to have much more detailed contract provisions and project information because large IPPs can have a material effect on utility system economics and reliability. The non-price terms and conditions under which the purchasing utility proposes to buy power are just as important as the price. The preparation by NEK of a model contract which addresses the principal non-price concerns of investors (such as discussed in Recommendation 6) and allocates risk fairly, could only serve to promote the rapid development of independent power in Bulgaria.



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# Appendix A

# Map of Bulgaria Power System

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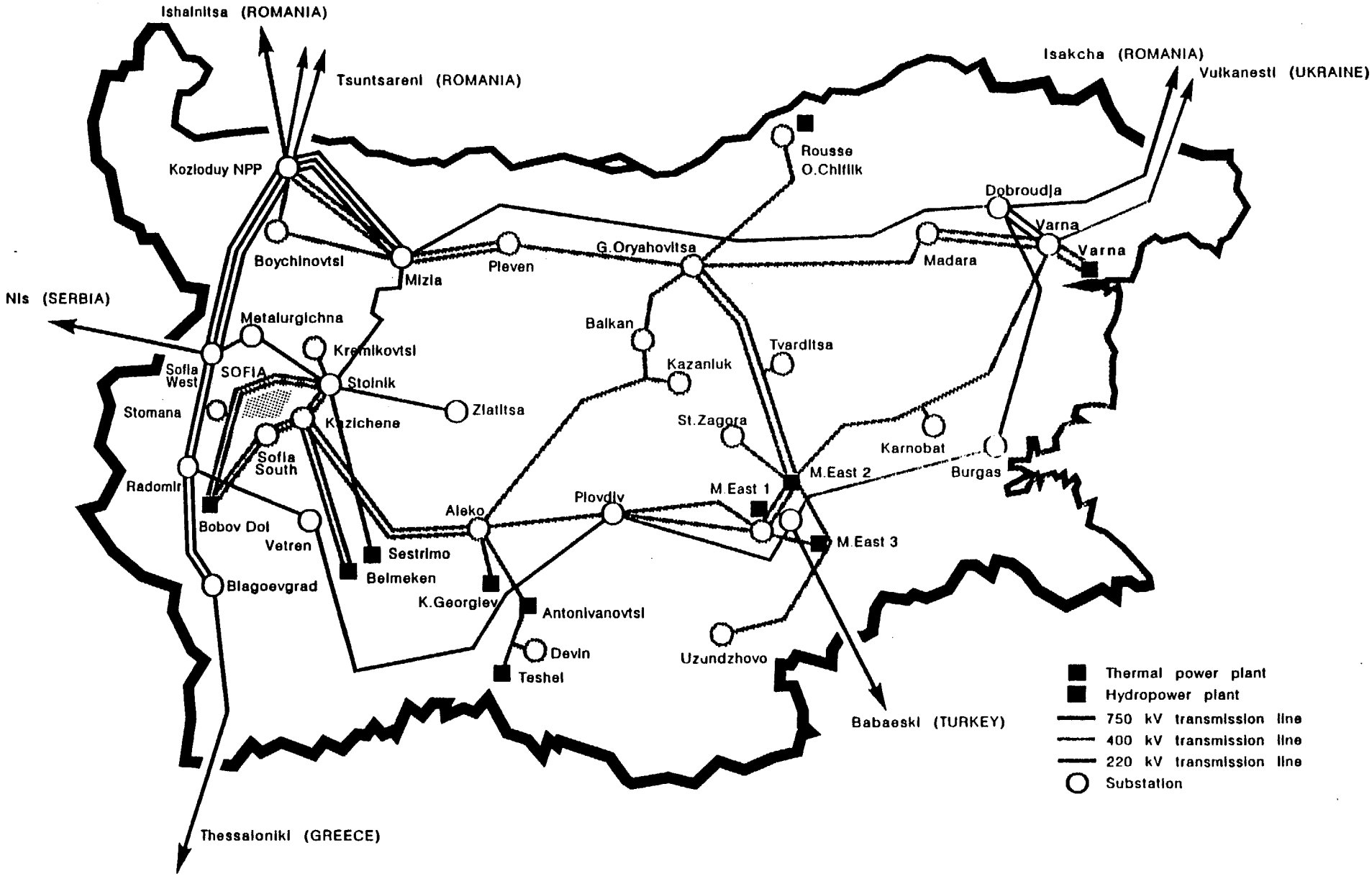
# Electric power system of Bulgaria




Source: NEK

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Similarly, as noted in the body of this report, there are other statutes which have ambiguities which could inhibit development of an independent power sector in Bulgaria. The privatization law, for example, apparently provides to former landowners preemptive rights



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in state or municipal enterprises built on expropriated land, and makes voidable certain "disposal transactions," presumably sales, under "unfavorable conditions." Ambiguities also exist in other statutes, for example the Law on Ownership and Use of Agricultural Lands, which may make it difficult to assure clear title to prospective purchasers of formerly agricultural land. It is, therefore, recommended that a comprehensive review of all Bulgarian laws affecting the environment or property rights be undertaken, with the goal of identifying and clarifying any potential conflicts or inconsistencies.

### 2) Establish Power Sector Regulatory Institution and Ensure Staffing by Qualified Regulators

The absence of any history of utility regulation in Bulgaria makes it imperative that any such regulatory body be established both with clearly defined functions and authorities, with qualified staff and with resources adequate to fulfill their responsibilities. As the Bulgarian Government completes its deliberations over the regulatory model to be used, a study of necessary resources will need to be performed. Issues to be addressed at a minimum would be:

- Staffing and training of regulatory commission personnel in generation expansion planning and integrated resource planning;
- training of regulatory commission personnel in finance and accounting;
- hardware and software necessary to monitor and corroborate the integrated resource plans of the franchised utilities; and
- training of regulatory commission personnel in utility operational issues.

### 3) Develop and Publish Detailed Regulations

The evolving and dynamic nature of regulation in the power sector in countries worldwide, combined with the unaccustomed responsibilities of the entities implementing Bulgaria's utility regulatory systems, will give rise to concern by prospective investors about arbitrary or capricious administration of the regulatory policies. It is, therefore, important that the implementing regulations define with precision the requirements, for example, for timing and approval of generation expansion needs. It is recommended that the regulatory body consider requiring significant detail in utility IRP submittals while allowing NEK enough flexibility to optimize the process over time. Such details might include, in addition to the usual procedural guidelines, substantive technical requirements for type, format and availability of data, and modeling protocols, analyses and results.

The regulations will need to also set out detailed requirements for solicitations or proposals to supply additional capacity. These requirements should assure that capacity expansions and renovations are consistent with the Integrated Resource Plan and other policies of the Bulgarian government. Such regulations might prohibit the recovery of capital



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investments made by NEK without authorization of the regulatory body and require the solicitation and analysis of alternative proposals prior to authorizing the utility to proceed with its own construction.

### 4) Establish Central Information Clearinghouse for IPP Developers

In order to counteract the unfamiliarity of many potential investors with Bulgaria and its institutions, it is recommended that the Committee of Energy (COE) or NEK assemble and make available information on the institutional framework, as well as technical data, such as hydrology at prospective hydroelectric sites or thermal demand at cogeneration facilities, which would be of interest to project developers.

COE or NEK would be advised to consider making the information on the utility's least-cost plan assumptions, modeling methodology and results available to prospective investors. Most importantly, this would allow project developers to optimize their project configurations to the needs of (and the benefit of) the utility system. It would also give investors added comfort that the technical and economic evaluation process is handled equitably.

Finally, it is recommended that an information package providing potential power developers with relevant details about conditions in Bulgaria be prepared and distributed on request and at industry conferences.

### 5) Use Integrated Resource Planning (IRP) to Establish Long-Run Marginal and Avoided Cost pricing and Project Selection

One goal of the IRP planning process should be to establish the power project costs from which project developers as well as utility planners can evaluate the cost-effectiveness of their proposals. It should be recognized that these cost figures will change over time based on the state of technology and market conditions. In the face of uncertainty, the fair estimation of such costs is an essential component of rational utility and IPP decision making. It is also necessary to provide independent suppliers with a fair price for their production while protecting the utility from paying windfall profits to those suppliers.

Proposed projects large enough to have an impact on system economics should be evaluated in the utility's model and compared to the utility's base case plan with respect to economics and reliability.

### 6) Establish Consistent Policy Regarding Government Guarantees of Utility Performance

Given the limited experience of NEK and other Bulgarian public and private entities in operating as financially sound and independent institutions, it is highly likely that a foreign



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investor and developer would require the Government of Bulgaria (GOB) to provide guarantees and other incentives. For instance, the GOB may need to guarantee that NEK will honor its commitments in the power purchase agreement with a developer. Should NEK, for whatever reason, not be able to pay the developer according to the terms of a signed power purchase agreement, the GOB would provide the financial resources necessary to honor the contract. Developers may also seek guarantees from the GOB regarding the performance of government-owned fuel suppliers and the National Bank of Bulgaria. Finally, it is likely that the GOB will be asked for support with respect to foreign exchange availability, force majeure, and other related issues.

Based on the requirements in the international independent power market, the GOB will need to develop a policy regarding what types of guarantees and incentives it is willing to provide. In the early phases of developing Bulgaria's independent power market, it may be necessary to provide substantial guarantees and assistance, but as the IPP market matures and the perceived risks diminish, it would be possible to reduce the type and scope of support offered.

### 7) Establish Policy for Soliciting Independent Power

NEK may chose to negotiate with the proponents of unsolicited proposals in the early phases of IPP market development in order to overcome the unfamiliarity of project sponsors with conditions in Bulgaria. In more mature market phases and when project precedents have been established, it may be desirable to move to a competitive bidding format. The advantage of competitive bidding is that it can result in lower electricity rates and more favorable terms for the utility and the consumer. Given the substantial costs of preparing an independent power proposal, however, competitive bidding can slow down the project selection process and discourage participation by developers.

### 8) Establish and Train a Multi-Disciplinary Review and Negotiations Team

In order to protect the purchasing utility's interest while allowing for expeditious selection of project proposals and resolution of unresolved contract issues with their sponsors, it is recommended that a multi-disciplinary review and negotiation team be established at NEK. The team should be comprised of engineers with experience in generation, transmission and distribution operations, fuel procurement, planning and central dispatch. It would also include lawyers specialized in Bulgarian administrative law and procedure. All members of the team would receive training in the principles of contract law and international and project finance.

## 9) Provide Standard Offer Contracts for Small Renewable and Cogeneration Projects

The development of smaller projects can prove significant to Bulgaria by expanding the use of indigenous energy resources and renewable fuels. However, the transaction costs associated with extended negotiations of price and terms with a purchasing utility can be a major deterrent to potential investors. The elimination of this deterrent through establishment of a "Standard Offer" is recommended.

To implement this recommendation, it will be necessary to establish a class of favored generation technologies and a maximum size for each project which will permit economic development of the resource and the project without adversely affecting NEK's planning or operating characteristics. It will also be necessary to establish a purchase tariff (including terms and conditions) which is structured to assure reliable operation of the facility and pricing which fairly reflects avoided costs. Energy price indexing should be considered, as should capital cost indexing. The terms of the Standard Offer would be non-negotiable; nonetheless the project sponsor would create an effective long-term contract by merely signing and delivering the offer.

## 10) Provide Standard non-Price Terms for Large Projects

For larger projects it is not recommended to provide "Standard Offer" contracts. NEK will need to have much more detailed contract provisions and project information because large IPPs can have a material effect on utility system economics and reliability. The non-price terms and conditions under which the purchasing utility proposes to buy power are just as important as the price. The preparation by NEK of a model contract which addresses the principal non-price concerns of investors (such as discussed in Recommendation 6) and allocates risk fairly, could only serve to promote the rapid development of independent power in Bulgaria.



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# Appendix B

# Statistics on Major Power Project Rehabilitation and Repowering Opportunities in Bulgaria

## BULGARIA DISTRICT HEATING PLANT REHABILITATION/REPOWERING OPTIONS

| District Heating Plant | Retirement Year | Rehab Year | Power After Rehab (MW) | Increase in MW | Rehab Cost $/kW |
|---|---|---|---|---|---|
| Sofia | | | | | |
| Unit 4 | 1994 | | | | |
| Unit 5 | 1994 | | | | |
| Unit 6 | 2010 | 1995 | 104 | 99 | 300 |
| Unit 8 | 2011 | 1996 | 240 | 220 | 300 |
| Tsaicho Kostov | | | | | |
| Unit 1 | 2010 | 1995 | 142 | 122 | 275 |
| Unit 2 | 2010 | 1995 | 142 | 122 | 275 |
| Unit 3 | 2011 | 1996 | 142 | 122 | 275 |
| Unit 4 | 2011 | 1996 | 142 | 122 | 275 |
| Unit 5 | 2011 | 1996 | 312 | 257 | 275 |
| Russe | | | | | |
| Unit 1 | 1998 | | | | |
| Unit 2 | 2000 | | | | |
| Unit 3 | 2010 | 1995 | 110 | 25 | 225 |
| Unit 4 | 2011 | 1996 | 110 | 25 | 225 |
| Unit 5 | 2013 | 1998 | 60 | 10 | 315 |
| Unit 6 | 2015 | 2000 | 60 | 10 | 315 |
| Shuman | | | | | |
| Unit 1 | 2010 | 1995 | 54 | 50 | 482 |
| Unit 2 | 2011 | 1996 | 82 | 78 | 488 |
| Unit 3 | 2011 | 1996 | 46 | 42 | 472 |
| Republica, Pernick | | | | | |
| Unit 2 | 1993 | | | | |
| Unit 3 | 2009 | 1994 | 30 | 10 | 50 |
| Unit 4 | 2009 | 1994 | 25 | 5 | 50 |
| Unit 5 | 2010 | 1995 | 55 | 15 | 50 |
| Unit 6 | 2026 | | | | |
| Pleven | | | | | |
| Unit 1 | 2012 | 1997 | 83 | 75 | 466 |
| Unit 2 | 2012 | 1997 | 94 | 86 | 473 |
| Unit 3 | 2013 | 1998 | 118 | 110 | 486 |
| Plovdiv | | | | | |
| Unit 1 | 2005 | | | | |
| Unit 2 | 2011 | 1995 | 119 | 99 | 308 |
| Unit 3 | 2009 | 1994 | 142 | 122 | 275 |

Source: World Bank, Bulgaria Power Demand and Supply Options, May 4, 1993

## BULGARIA INDUSTRIAL PLANT REHABILITATION/REPOWERING OPTIONS

| Industrial Plants | Retirement Year | Rehab Year | Power After Rehab (MW) | Increase MW | Rehab Cost $/kW |
|---|---|---|---|---|---|
| Burgas | | | | | |
| Unit 1 | 2012 | 1997 | 498 | 398 | 300 |
| Unit 2 | 2012 | 1997 | 584 | 524 | 289 |
| Devnia | | | | | |
| Unit 2 | 2010 | 1995 | 332 | 292 | 340 |
| Unit 3 | 2011 | 1996 | 162 | 152 | 344 |
| Unit 4 | 2011 | 1996 | 122 | 112 | 357 |
| Kremikovtzi | | | | | |
| Unit 1 | | | | | |
| Unit 2 | 2013 | 1998 | 238 | 193 | 306 |
| Unit 3 | 2013 | 1998 | 238 | 228 | 307 |
| Vratsa | 2013 | 1998 | 284 | 244 | 274 |
| Stara Zagora | | | | | |
| Unit 2 | 2013 | 1998 | 236 | 224 | 356 |

Source: World Bank, Bulgaria Power Demand and Supply Options, May 4, 1993

## MAJOR BULGARIAN POWER PLANT CANDIDATES FOR REHABILITATION

| Plant | Retirement Year | Rehab Year | Power After Rehab Gross MW | Increase in Output MW | Rehab Cost $/kW |
|---|---|---|---|---|---|
| Maritsa East 2 | | | | | |
| Unit 1 | 2010 | 1995 | 150 | 30 | 141 |
| Unit 2 | 2011 | 1996 | 150 | 30 | 141 |
| Unit 3 | 2012 | 1997 | 150 | 30 | 141 |
| Unit 4 | 2013 | 1998 | 150 | 30 | 141 |
| Unit 5 | 2014 | | | | |
| Unit 6 | 2015 | | | | |
| Unit 7 | 2018 | | | | |
| Unit 8 | 2022 | | | | |
| Varna | | | | | |
| Unit 1 | 2010 | 1995 | 210 | 0 | 221 |
| Unit 2 | 2010 | 1995 | 210 | 0 | 221 |
| Unit 3 | 2010 | 1995 | 210 | 0 | 221 |
| Unit 4 | 2011 | 1996 | 210 | 0 | 141 |
| Unit 5 | 2011 | 1996 | 210 | 0 | 141 |
| Unit 6 | 2012 | 1997 | 210 | 0 | 141 |
| Bobov Dol | | | | | |
| Unit 1 | 2009 | 1994 | 200 | 20 | 173 |
| Unit 2 | 2010 | 1995 | 200 | 20 | 173 |
| Unit 3 | 2011 | 1996 | 200 | 20 | 173 |

Source: World Bank, Bulgaria Power Demand and Supply Options, May 4, 1993

# Appendix C

# Standard Power Purchase Contract Between NEK and District Heating or Industrial Cogenerators

**Standard 1993 Contract**
**Between NEK and**
**District Heating or Industrial Cogenerators**

Today, 1993, in Sofia, between:
_____, represented by
_____, hereafter called "IPP", on the one side
and Natzionalna Elektricheska Kompania - Joint Stock Company, represented by the Chairman of the Board of Directors DYANKO DOBREV, hereafter called "NEK" concluded this contract, as follows:

## I. SUBJECT OF THE CONTRACT

**Article 1.** Subject of this contract is the insurance of parallel work of the generating capacity of the IPP with the country's electricity system and the purchase of electricity during 1993.

NEK maintains the electricity system in normal condition of parallel work and ensures the supply to the consumers of the IPP in case of failure.

## II. TECHNICAL AND ORGANIZATIONAL CONDITION

**Article 2.** The electricity is scheduled by quarters, months and tariff zones according to the specification which is an integral part of this contract.

In case a change in the quantities of electricity is needed, the parties make the required amendments of the contract not later than 5 days before the end of the respective quarter.

**Article 3.** The Maintenance and Repair Program of the generators of the IPP with fixed starting dates and length is coordinated with NEK. The changes should be coordinated in writing 5 days before small-scale repairs or 30 days before capital repairs.

Turbogenerators or stream generators can be disconnected and repairs can be conducted after approval of an operational application by the District Dispatch.

SP

**Article 4**. When requested by the Central Dispatch, the IPP is obliged to change the reactive power of the generators within the limits of their technical specifications.

Compliance with this obligations is ascertained by monthly revision of the meters for reactive energy on the generators of the IPP and of the hourly records of the reactor power in the operational journals of the IPP.

**Article 5**. The IPP will sell the agreed electricity on the basis of load on the steam extraction according to the characteristics of the turbogenerators which are an integral part of this contract.

**Article 6**. On request by the Central Dispatch for greater quantities of electricity than produced by the IPP according to the steam extraction by taking into operation additional spare equipment for a definite period of time, NEK pays the additional quantities at a price 20% higher than the average for the month, against an invoice according to the provisions of Article 12.

The two parties are obliged to fix the beginning and the end of such an event in the respective operational journal of the District Dispatch and the IPP.

The quantity of electricity under this article is determined by a bilateral protocol between the respective District Dispatch of NEK and the IPP, which is prepared on the basis of the records in the operational documentation.

**Article 7**. The IPP is obliged to keep the equipment in good condition, to exercise control and to notify NEK immediately in case of switch-on of the relay protection, automation and signalization of the equipment, related to the functioning of the electricity system, as well as of the communication means and telemechanics.

**Article 8**. The IPP is obliged to keep in good condition the devices for automatic frequency disconnection and the other automatic regulation devices, so that its own demands, the demands of the clients of the IPP and some important clients of the electricity system are met in case of disconnection of the IPP.

The set-up of the relay protection and automatics, ensuring the combined work of the IPP with the electricity system in normal and emergency regimes, is in the competence of the NEK's bodies and is carried out against payment when caused by changes in the IPP.

The IPP is obliged to follow all NEK's instructions with regard to the relay protection and automatics, including the after-failure tests of these devices.

**Article 9**. The IPP is obliged to execute the orders, issued by the District Dispatch or NEK, related to the functioning of the equipment which is operationally linked with the District Dispatch and the Central Dispatch, in compliance with the instructions for operational management of the electricity system.

## III. MEASURING AND PAYMENT OF ELECTRICITY

**Article 10**. The purchased electricity will be measured by means of electrometers for active and reactive energy, provided and installed by the IPP on the property borderline between the equipment of the two parties.

The reading of the electrometers is done at 0 a.m. on the first date of each month by authorized representatives of the contracting parties, who draw up a protocol for the purchased during the month electricity.

Testing, regulation and replacement of the electrometers, according to which the electricity is measured and purchased, is carried out at the request of one of the parties in the presence of representatives of both parties.

**Article 11**. The IPP sell to NEK the contracted quantity of electricity according to the indications of the three-tariff electrometers for the respective month for the tariff zones.

**Article 12**. The payment for the electricity is effected by direct bank remittance by payment order at prices according to the actual Electricity Tariff.

The IPP is obliged to submit to NEK an invoice for the quantity of electricity sold during the previous month not later than the fifth day of the current month.

NEK submits a payment order to the servicing bank on the day following the day of receipt of the invoice.

In case of delayed payment, NEK pays the central interest rate on the amount due.

## IV. PENALTIES

**Article 13**. In case of violation of Art. 3, Art. 4, Art. 8 and Art. 9 the IPP pays NEK a penalty amounting to 0.05% of the value of the quantity of electricity contracted for the respective month.

Violation of the contract are ascertained by a commission, comprising members of both parties.

**Article 14**. In case the purchased electricity exceeds or is less by more than 5% than the contracted amount, the IPP pays NEK a penalty for the difference, amounting to 10% of its value.

The IPP assumes no liability for electricity not supplied because of damages in the transmission equipment of NEK.

In cases of natural disaster (acts of God), both parties are exempted from liability.

## V. GENERAL PROVISIONS

**Article 15**. The parties are obliged to exchange lists of the names of the officials, authorized to take operational decisions, as well as of those, responsible for measuring the purchased electricity.

**Article 16**. The addresses and the bank accounts of the parties are:

VENDOR:
Company: _____
Headquarters Address: _____
Court of Registration: _____
Number of Registration: _____
Bank Account: _____

BUYER:
NEK Joint Stock Company
Sofia, 8 Triaditza Street
Registered with the Sofia District Court
Number of Registration: 196, volume 5, register II, p. 98
Bank Account: 421 130 165 - 001 - 5, Commercial Bank "Sofia"

If changes in the registration , addresses or bank accounts occur, the parties are obliged to send notification in writing within a period of 5 days.

**Article 17**. This contract can be amended, supplemented and extended by bilateral written agreement between the parties.

**Article 18**. Issues not addressed by this contract will be subject to the existing normative acts.

**Article 19**. Disputes between the parties concerning the implementation of this contract shall be solved by negotiations. When no agreement is reached, the dispute shall be decided upon by voluntary arbitration at the Bulgarian Chamber of Commerce and Industry.

Integral part of this contract are the specification, the repair program, and the regime characteristics of the turbogenerators.

This contract has been prepared in two uniform copies, one for each party, and takes effect on the day of signature.

VENDOR:

_____

_____

BUYER:
NEK
Chairman
/D. Dobrev/

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# POWER SECTOR ENVIRONMENTAL ISSUES

Job No. 21954-000

Bechtel

December 1992

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# GLOSSARY

| | |
|---|---|
| AAQS | ambient air quality standards |
| CAA | Clean Air Act |
| CFC | Chlorofluorocarbon |
| DOE | Department of Energy |
| EEC | European Economic Community |
| EMF | electromagnetic fields |
| EPA | Environmental Protection Agency |
| EPRI | Electric Power Research Institute |
| ESP | Electrostatic Precipitation |
| FGD | flue gas desulfurization |
| MAC | maximum allowable concentrations |
| VOC | Volatile Organic Compounds |
| ME-1 | Maritza East 1 |
| NG | natural gas |
| MW | megawatts |
| NCI | National Counsel Institute |
| NEC | National Electricity Committee |
| PVC | polyvinyl chloride |
| SCR | selective catalytic reduction |
| SI | sorbent injection |
| TPY | metric tons per year |
| WHO | World Health Organization |

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POWER SECTOR

ENVIRONMENTAL ISSUES

## 2.0 EXECUTIVE SUMMARY

### 2.4 Power Sector Environmental Issues

The purpose of this study was to provide an assessment of fossil-fired power plant in terms of current and future emission control requirements. Six existing thermal power plants and their fuel supplies were reviewed. The plants were: (1) Maritza East 1, (2) Maritza East 2, (3) Maritza East 3, (4) Varna, (5) Bobov Dol, (6) Ruse.

The plants current operational status, fuel sources and emission control are examined as a result of this examination. Various recommendations were made in terms of what could be achieved in the immediate, short term, and long term. In addition, the plants were ranked based on age, heat rate, and potential emission control costs.

The recommendations were presented in the form of environmental strategies. They covered the areas of plant and mining enhancements, emission controls, and plant betterment related changes. These recommendations requirement further, more

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detailed examination of a plant by plant basis for suitability. One of the goals of this report was to provide an overall framework for plant specific detailed investigations.

By implementing plant changes in a phased manner while developing alternative fuel sources, the economic impact on the Bulgarian energy industry can be reduced while quickly reducing the environmental impact of the fossil-fired thermal power plants. The following long term total emission reductions ($SO_2$, $NO_x$, TSP) appear feasible at relatively minimal costs of $50 to $75/kw or for total costs for all six thermal power plants considered of between $200 to 300 million:

| | Long Term Reductions: |
|---|---|
| Maritza East I | 54% |
| Maritza East II | 78% |
| Maritza East III | 48% |
| Varna | 48% |
| Bobov Dol | 52% |
| Ruse | 48% |

Potential long term $SO_2$, particulate and $NO_x$ reductions on a six plant basis along with associated costs are:

| | Long Term Reductions | Capital Cost $1000 |
|---|---|---|
| $SO_2$ | 62% | 99,000 |
| Particulate | 77% | 158,400 |
| $NO_x$ | 38% | 41,700 |



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All plants will require some form of $SO_2$ and $NO_x$ control and an improvement in particulate control. Emphasis should be placed on utilizing the Maritza East power plants and associated coal mining area while completing Unit 8 at Maritza East II since the coal can be mined economically.

The Varna, Ruse and Bobov Dol plants would have reduced emissions through additional control technology and through switching to lower sulfur coals or possibly natural gas as it becomes available. If high ash and sulfur Bulgarian lignite coals continue to be used, different combustion technologies such as fluidized bed boilers may be appropriate to replace aging boilers.



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# 13.0 INTRODUCTION

## 13.1 Purpose

This study provides an assessment of the environmental aspects of fossil-fired power plant modernization in conjunction with current and future emission control requirements. Selected fossil-fired plants were be examined in this study in terms of their current operation, their potential for emission reduction, and the associated costs for emission and environmental control. A $NO_x/SO_2$ and particulate control strategy is provided as a result of this examination.

## 13.2 Scope and Approach

Scope

The study considered six existing thermal power plants in terms of their current status and operating characteristics, current fuel sources, and emissions controls. The study then examined the extent to which added emission controls could be applied to the existing plants to meet current and future source emissions limits. Costs for additional emissions controls are determined including capital, operation and maintenance costs associated with plant modifications and associated raw material and waste disposal requirements.

The plants examined in the study were:



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(1) Maritza East 1, (2) Maritza East 2, (3) Maritza East 3, (4) Varna, (5) Bobov Dol, and (6) Ruse.

Approach to Study

The approach to the study had several interrelated elements and objectives including:

- Development of current information for each power plant which would enable an evaluation of the feasibility adding of more stringent emission control equipment or otherwise reducing emissions.

- Collection of current plant and emission data through plant visits, interviews with plant staff, and review of published information in order to understand plant operations. This became the basis for selected $NO_x$ and $SO_2$ emission control measures.

- Utilization of industry sources on emission control technology including studies wherein the issues of plant betterment, plant and mine modernization, environmental control, waste minimization and environmental issues are considered.

- Consideration of related energy and environmental studies in Bulgaria.



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- Provide results as early as possible regarding the individual and collective potential for plant betterment, emission control and related matters as part of an overall $NO_x$ and $SO_2$ control strategy.

- Represent the results of the study in tabular form to the extent necessary for ease of understanding and maximum assimilation.

- Highlight study issues and actions which would require either immediate attention or the attention of others regarding Bulgaria's electricity system planning, organization, development decisions and/or investment relating to environmental protection, air pollution control and/or plant betterment.

## 14.0 THERMAL POWER PLANTS EXAMINED

Six fossil-fired power plants were included in this study. These are Maritza East 1, Maritza East 2, Maritza East 3, Varna, Bobov Dol, and Ruse thermal power plants. The following provides a brief description of each of these plants in terms of plant capacity, heat rate, fuel, cooling and makeup water, and pollution control measures or equipment. Table 14-1 provides a summary tabulation of this information.

### 14.1 Maritza East 1 Thermal Power Plant

The Maritza East 1 Thermal Power Plant (ME-1) is located near the town of Golubovo in central Bulgaria. This 200 MW plant consists of 4 - 50 MW units which burn lignite from the Maritza East mine. Roughly two-thirds of the coal burned in this plant is used to produce steam for the coal briquette plant. Fuel characteristics are ash (35%), moisture (55%), sulfur (2-5%), and heat value (about 1450 Kcal/kg).

Table 14-2 provides heat rate information for the power plants. This will be used to evaluate possible actions for each plant.

Cooling of the plant is via the Boswell Reservoir that is located on the Sazlicka River.

Fuel gas treatment consists of electrostatic precipitators (ESPs) and two 325 meter stacks. The ESPs have an efficiency of about 98%. The high stacks help disperse the plant emissions. 70% efficient cyclones are used to control emissions from the coal drying plant.

Table 14-1

Summary Thermal Plant Characteristics
Bulgaria Electricity Study

| Name | Fuel | Installed Capacity (MW) | Boiler Units (T/HR) | Turbine Units (MW) | Makeup/Cooling Water System | Pollution Control |
|---|---|---|---|---|---|---|
| 1. <u>VARNA Thermal Power Plant</u><br><br><u>Staff</u> - 950 (130 non-production) | Bituminous Coal, and Natural Gas<br><br>Coal imported from Donbas field in the Ukraine with 10,000 ton ships.<br><br>●Moisture - 9%<br>●Ash - 20%<br>●Sulfur - 1.8%<br>●Heating Value - 5800 Kcal/Kg<br><br><u>Consumption</u><br>1990 - 2.5 MTPY<br>1987 - 2.5 MTPY | 1260 | 6 - 670 | 6 - 210 | <u>Cooling</u><br>Open cycle to L. Varna which is arm of Black Sea.<br>ΔT 6-8°C<br><br><u>Makeup</u><br>Wells 120-150 meters deep.<br>Consumption 125 T/hr at peak, currently at 90 T/hr. | <u>Water</u><br>Wastewater to ash pond; water collected and released to L. Varna. Waters regularly sampled and tested.<br><br><u>Air</u><br>ESPs<br>Units 1-3 98-98.5%<br>Units 4-6 99%<br>2 - Stacks<br><br><u>Solid Waste</u><br>Ash hydraulically transported to ash pond. |
| 2. <u>BOBOV DOL Thermal Power Plant</u><br><br><u>Staff</u> - 1060 | Subbituminous coal from Oranovo Mine (15%) and Bobov Dol Mine (85%).<br><br>●Heating value - 2400 Kcal/Kg<br>●Ash - 50%<br>●Moisture - 16%<br>●Sulfur - 1.7 %<br><br><u>Consumption</u><br>1991 - 0.8 MTPY | 630 | 3 - 650 | 3 - 210 | TBD | <u>Water</u><br>Wastewater to ash pond<br><br><u>Air</u><br>ESPs<br><br><u>Solid Waste</u><br>Ash ponds |

| Name | Fuel | Installed Capacity (MW) | Boiler Units (T/HR) | Turbine Units (MW) | Makeup/Cooling Water System | Pollution Control |
|---|---|---|---|---|---|---|
| 3. MARITZA EAST I Thermal Power Plant<br><br>Staff - 1229 | • Lignite - mine mouth from Maritza East Mine<br><br>• Some waste from briquette factory adjacent<br><br>• Fuel drying plant included<br><br>• Ash - 35%<br>• Moisture - 55%<br>• Sulfur - 2-5%<br>• Heating Value - 1400 Kcal/Kg<br><br>Consumption<br>3.2 MTPY | 200 | 5 - 210<br>4 - 250 | 4 - 50 | Open cycle cooling from the Boswell Reservoir on the Sazlicka River | Water<br>Solid and liquid wastes to ash pond<br><br>Air<br>ESPs<br>2 - stacks<br><br>Solid Waste<br>Ash pond |
| 4. MARITZA EAST 2 Thermal Power Plant<br><br>Staff - 2067 (137 non-production) | • Lignite from Maritza East Lignite Mine and the Troyanovo Mine and transported by rail<br><br>• Heating value - 1320 to 1600 Kcal/Kg<br>• Sulfur - 1.7-2.3%<br>• Moisture - 52-58%<br>• Ash - 12-23%<br><br>Consumption<br>12 MTPY (40,000 TPD) | 1230 | 8 - 250<br>4 - 670 | 4 - 150<br>3 - 210 | Open cycle cooling from Lake Orohiritza (units 1-6); cooling tower (units 7-8).<br>ΔT 8-12°C | Water<br>Wastewater to ash pond<br><br>Air<br>ESPs - 99% removal<br>2 - 300 meter stacks<br><br>Solid Waste<br>Ash pond |

| Name | Fuel | Installed Capacity (MW) | Boiler Units (T/HR) | Turbine Units (MW) | Makeup/Cooling Water System | Pollution Control |
|---|---|---|---|---|---|---|
| 5. MARITZA EAST 3 Thermal Power Plant<br><br>Staff - 1500 (100 non-production) | Lignite from Troyanovo South Mine and transported by conveyor.<br><br>• Ash - 34% (range from 28-45%)<br>• Moisture - 54% (range from 49-56%)<br>• $SO_2$ - 1.6-2.4<br>• Btu - 1420 Kcal/Kg<br><br>Consumption<br>9.3 MTPY | 840 | 4 - 670 | 4 - 210 | Cooling Tower | Water<br>Wastewater to ash pond. Water reclaimed from bottom drains for recycle to plant. Cooling tower blowdown and unneeded plant water discharged to Sokolista River.<br><br>Air<br>ESPs - 98% removal<br>1 - 325 M stack<br><br>Solid Waste<br>Ash pond and ash returned to mine |
| 6. Ruse Thermal Power Plant<br><br>Staff - 677 | Imported bituminous coal from Donbas Coal field in the Ukraine and barged up Danube River<br><br>• Ash - 20%<br>• Moisture - 8%<br>• Sulfur - 2%<br>• Heating value - 5800 Kcal/Kg<br><br>Consumption<br>0.5 MTPY | 400 | 2 - 365<br>6 - 220 | 2 - 110<br>2 - 60<br>2 - 30 | Open Cycle - Danube River | TBD |

TABLE 14-2

## Heat Rates of Thermal Power Plants

| Plant | Power MW | Coal Rate Kg/hr | Coal Rate TPY | Heat Content Kcal/kg | Heat Content Btu/lb | Heat rate Btu/kwhr | Remarks |
|---|---|---|---|---|---|---|---|
| Maritza East I | 200 | N/A | 3,141,711 | 1450 | 2615 | 18298 | Note 1 |
| Maritza East II (4 old units) | 600 | N/A | 5,649,089 | 1450 | 2615 | 13807 | Notes 2, 3, and 8 |
| Maritza East II (3 newer units) | 630 | N/A | 3,717,512 | 1450 | 2615 | 10931 | Notes 2, 3, and 8 |
| Maritza East III (4 boilers/STG) | 840 | 1,468,000 | 9,338,000 | 1450 | 2615 | 10054 | Notes 4 and 8 |
| Varna | 1260 | N/A | 2,500,000 | 5800 | 10460 | 9856 | Notes 6 and 7 |
| Bobov Dol | 630 | 768,000 | 800,000 | 2400 | 4328 | 11608 | Note 4 and 9 |
| Ruse | 400 | N/A | 500,000 | 5800 | 10460 | 21199 | Notes 6 and 7 – no credit taken for thermal use (district heating) |
| Total | 4560 | | 25,646,312 | | | | |
| Average Heat Rate (Power Production Only) | | | | | | 11251 | M.E. I and Ruse not included since they have thermal users. |

Notes:

1. Per reference 11 (Maritza E. 1 TPP description) – calculated heat rate takes no credit for thermal use. The heat rate calculation is based on annual generation (989999 thousand kWh divided by annual coal consumption.
2. Coal Heat Content from 3/30/92 trip report and attached coal data.
3. Heat rates from p. 67 of Bulgaria Energy Strategy Study (Ref.22) – 2.4 kg coal/kwh for 4–150 MW older units of ME II, and 1.9 kg coal/kwh for the three new 210 MW units.
4. Based on Energoproekt data on coal feed rate to each boiler (367 t/hr) attached to a trip report dated Mar. 30, 1992.
5. Plant capacities from ref. 22 (p. 58 of Bulgaria Energy Strategy Study)
6. List of fuel types obtained in June, 1992.
7. Heat rate based on annual coal consumption and electical production data on Tables A.3.1 and A.4.4 for 1990 from the Bulgaria Energy Strategy Study (1990 net output; Varna – 5850 M kwh, Ruse – 544 M kwh).
8. Coal rates in TPY are based on 1991 data from Maritza E. II and III descriptions (ref. 11). ME II TPY have been divided allowing for power and heat rate differences and based on total ME II TPY of 9,168,000.
9. Bobov Dol coal rate in TPY based on a 7/28/92 trip report.

## 14.2 Maritza East 2 Thermal Power Plant

The Maritza East 2 Thermal Power Plant is a 1230 MW plant which consists of 4 -150 MW, 3 - 210 MW units and another 210 MW unit (Unit 8) under construction. With the completion of Unit 8, the total capacity of the station will be 1440 MW. Units 1 - 6 are served by one stack and units 7 and 8 by a second stack. The plant has once-through cooling, but units 7 and 8 depend on a cooling tower for cooling. Units 1 - 6 are served by Lake Orchiritza for cooling purposes. The plant burns lignite from the Maritza East and Troyanovo mines. Fuel characteristics are ash (12-23%), moisture (52-58%), $SO_2$ (2-5%), and heating value (1320-1600 Kcal/kg).

Coal is transported to the plant by rail. Coal is conveyed by dual conveyors to the plant from the coal storage area.

Ash, wastewater and slag is transported hydraulically to the ash pond. Water is recycled to the plant. Electrostatic precipitators with an efficiency of 99% removal serve the plant. The plant is served by 2 - 300 meter stacks.

## 14.3 Maritza East 3 Thermal Power Plant

The Maritza East 3 Thermal Power Plant is a base load condensing thermal power plant with an installed capacity of 840 MW. It is located near Mednikarovo near the city of Stara Zagora. The plant is near the Troyanovo 3 open pit coal mine. The plant consists of 4 - 670 ton/hour boilers which supply steam to 4 - 210 turbine generators. The boilers are

designed for direct burning of coal. Fuel characteristics are ash (34%), moisture (54%), $SO_2$ (2.0-5.0%), and heating value (1420 Kcal/kg).

Coal is transported from the Troyanovo 3 open pit mine by an open conveyor. Coal is transported to the coal storage area. Coal is reclaimed and conveyed using two belts of 2,400 ton/hour capacity. Provision exists for rail transport and unloading of coal at the plant. Coal pulverization system consists of eight mill fans and concentrators. Each boiler is supplied with two fans and 2 motors.

Fuel gas treatment consists of four electrostatic precipitators with about 98% removal capacity. One 325 meters stack serves the 4 - 210 MW plant. Ash is disposed in an ash pond using a closed-loop hydraulic system. Process water supply is based on a recirculation system with the two cooling towers.

## 14.4 Varna Thermal Power Plant

The Varna Thermal Power Plant consists of 6 - 210 MW units which burn bituminous coal and natural gas. Coal is imported from the Donbas coal field in the Ukraine. The coal is brought to the plant by ship and unloaded using bucket unloaders at the coal dock in to the storage pile or into the plant conveyor hopper. A plant conveyor/bucket unloader removes coal from the dock storage pile also and unloads into the plant conveyor. Fuel characteristics are moisture (9%), ash (20%), sulfur (1.8%), and heating value (5800 Kcal/kg). 1991 consumption was 1.8 million tons. 1987 consumption was 3.2 million tons.

Plant cooling is open cycle to Lake Varna which is an arm of the Black Sea. Makeup water is obtained from local wells. Wastewater, ash and slag are conveyed hydraulically to the ash pond. Surplus water from the ash pond is released to Lake Varna. Flue gas treatment consists of 6 electrostatic precipitators. ESPs for units 1-3 have an efficiency of 98-98.5% removal and for units 4-6, 99% removal.

## 14.5 Bobov Dol Thermal Power Plant

The Bobov Dol Thermal Power Plant is a 630 MW thermal power station which is located near Stanke Dimitrov. The plant consists of 3 - 210 MW turbines. Seventy percent (70% of the fuel is supplied from the Bobov Dol coal field at thirty percent (30%) from the Oranovo coal field. Main coal fuel characteristics are moisture (14.5%), ash (41%), heating value (2400 Kcal/kg). The plant coal handling system capacity is 1,200 tons/hour. The plant can be fired used in oil and fuel oil tanks are included on the site.

Each unit has mills designed for 32 tons/hour and 95,000 $m^3$/hr air, 2 inlet radial fans of 373,000 $m^3$/hr each and three I.D. fans of 540,000 $m^3$/hr each. Flue gas cleaning equipment consists of two electrostatic precipitators with 99% efficiency. One stack serves all three units.

Flyash, bottom ash, slag and wastewater are conveyed to the ash pond.

Plant makeup water is from Lake Djakovo on the Djerman River. Cooling water system consists of three cooling towers.



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## 14.6 Ruse Thermal Power Plant

The Ruse Thermal Power Plant is a 400 MW plant comprised of 2 - 110 units, 2 - 60 units and 2 - 30 units which burn imported coal from the Dobnas coal field in the Ukraine. Coal is barged up the Danube River. Fuel characteristics include moisture (8%), ash (20%), sulfur (2%) and heating value (5800 Kcal/kg). The plant has open-cycle cooling from the Danube.



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## 15.0 CURRENT AND PROJECTED EMISSION LEVELS AND LIMITS

### 15.1 Current Plant Emissions

The following identifies the current emissions for the plants studied and identifies current and projected emission limits which will be required for all thermal power plants in the future. Table 15-1 identifies the current emissions for the study plants. This includes emissions for particulates and sulfur dioxide and is based in average plant performance over the 1989 to 1992 period. Included in Table 15-1 is information on plant capacity for context.

### 15.2 Current and Projected Emissions Limits

Air Emission Standards

The air emissions standards for Bulgaria consists of ambient air quality standards (AAQS) and emission standards. The AAQS were established in 1969 and revised in 1984 and apply to 171 pollutants. The standards specify 30 minute and 24 hours averages for maximum allowable concentrations (MAC).

Emission standards were established in 1978 and revised in 1986. These apply to the same 171 pollutants as the AAQS. Emission standards are calculated using actual facility or source data and area based on the AAQS, stack height, gas flow and temperature.

Table 15-1

Average Power Plant Emissions, TPY
1989-1992

| Item | Maritza East 1 200 MW | Maritza East 2 1230 MW | Maritza East 3 840 MW | Varna 1260 MW | Bobov Dol 630 MW | Ruse 400 MW | TOTAL 4560 MW |
|---|---|---|---|---|---|---|---|
| $SO_2$ | 100,000 | 700,000 | 600,000 | 90,000 | 111,262 | 29,590 | 1,630,852 |
| Particulate (Dust) | 21,992 | 21,543 | 15,875 | 7,500 | 12,000 | 2,000 | 80,910 |
| $NO_x$ | 12,253 | 41,432 | 83,263 | 14,000 | 10,000 | 8,610 | 169,558 |
| CO | 1,102 | 6,604 | 11,000 | 3,328 | 4,348 | 2,000 | 28,384 |
| Total | 135,347 | 769,579 | 710,138 | 114,828 | 137,610 | 42,200 | 1,909,702 |

Individually sources may meet these emission standards, but a combination of stationary sources of emissions within a given area may lead to the exceedance of AAQS. Under the Helsinki Protocol $SO_2$ emissions in 1993 should not exceed 70% of the emissions in 1980 ($SO_2$ emissions were 1.2 million tons in 1980, 1.7 million tons in 1989 and 1.6 million tons in 1990). Thus, a reduction of approximately 360,000 tons is required from 1980 levels, or achieving a level of approximately 840,000 tons per year by 1993.

Table 15-2 identifies current and projected emission limits for existing plants as well as those constructed in the future. Limits for particulates, sulfur dioxide, nitrogen oxide and carbon monoxide are identified for four fuel types including local coal, imported coal, oil and natural gas.

## 15.3 Comparison and Evaluation

Table 15-3 indicates levels of emissions for existing and new power plants along with proposed emission limits.

Based on the goals indicated by these emission limits, Tables 15-3, 15-4 and 15-5 have been developed to reflect the current and long term emission reductions that are feasible and the associated costs.

Particulate Control. Table 15-3 presents costs associated with addition particulate control equipment as a long term action. This table shows current particulate emissions and forecasts reductions over the long-term reductions of from 50 to 100% using equipment

modifications and plant closings. The associated long-term capital cost is in the $160 million range.

With these modifications, more than 50% of the plants will meet the new plant emission limits. The other plants exceed those limits by up to 86%. To meet limits for all plants, additional actions such as coal blending or cleansing, using lower ash coal, or converting to fluidized bed boilers may be required.

Sulfur Dioxide Reduction. Table 15-4 presents costs associated with sulfur dioxide reduction equipment as a long term alternative. This table shows current sulfur dioxide emissions and forecasts long-term reductions of from 50 to 100% with control equipment and plant closings for an approximate long-term capital cost of about $100 million.

Even with the noted modifications, the plants do not meet the new plant emission limits. Other actions such as using lower sulfur coal, employing higher efficiency FGD technologies, or converting to fluidized bed boilers may be required.

Nitrogen Oxide Reduction. Table 15-5 presents costs associated with $NO_x$ reducing actions as short and long term activities. This table indicates current $NO_x$ emissions and presents long-term reductions of 50 to 100% from control equipment and plant closings at an associated cost of $100 million. By using sorbent injection (SI), this capital cost could be included as part of the $SO_2$ control equipment.



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About 40% of the plants can either meet or are close to meeting the new plant standards (Table 15-2). To achieve lower levels of $NO_x$ emissions, application of more efficient low-$NO_x$ burner technologies, combination $NO_x/SO_x$ removal systems, fuel switching, or possible conversion to fluidized bed boilers may be required.

Possible actions to reduce emissions and improve performance are discussed further in Section 16.



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Table 15-2

Current Emission Limits for
Existing and New Power Plants

| | Existing Plants (built prior to 1992) | | | | New Plants (built after 1992) | | | |
|---|---|---|---|---|---|---|---|---|
| | TSP | $SO_2$ | $NO_x$ | CO | TSP | $SO_2$ | $NO_x$ | CO |
| Local Coal | 200 | 3500 | 1000 | 250 | 100 | 650 | 600 | 250 |
| Imported Coal | 150 | 2000 | 1300 | 250 | 80 | 650 | 600 | 250 |
| Liquid Fuel | 50 | 1700 | 700 | 170 | 50 | 650 | 450 | 170 |
| Natural Gas | 10 | — | 500 | 100 | 10 | — | 300 | 100 |

All units $Mg/Nm^3$ and are based on 0°C, 760 mmHg, and 6% Oxygen for coal burning and dry ash transport, 5% $O_2$ for liquid fuels, and 3% $O_2$ for liquid and gas fuel.



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## TABLE 15–3
## PARTICULATE EMISSIONS IMMEDIATE, SHORT TERM AND LONG TERM REDUCTIONS

| | Current | | | | Immediate | | | | | | Short Term Reductions | | | | Long Term Reductions | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Power MW | Coal Rate TPY | Emiss. mg/ Nm3 | TPY | Curr. Effic. % | Red % | Emiss. mg/ Nm3 | TPY | Cap. Cost $k | Oper. Cost mills/ kwh | Red. % | Emiss. mg/ Nm3 | TPY | Cap. Cost $k | Oper. Cost mills/ kwh | Red. % | Emiss. mg/ Nm3 | TPY | Cap. Cost $1000 | Oper. Cost mills/ kwh |
| Maritza East I | 200 | 3,141,711 | 990 | 21992 | 98.0 | 0 | 990 | 21992 | 0 | 0 | 50 | 495 | 10996 | TBD | 0 | 88 | 124 | 2749 | $8,000 | 4 |
| Maritza East II (4 old units) | 600 | 5,649,089 | 142 | 12993 | 99.0 | 0 | 142 | 12993 | 0 | 0 | 100 | 0 | 0 | TBD | 0 | 100 | 0 | 0 | $0 | 0 |
| Maritza East II (3 newer units) | 630 | 3,717,512 | 142 | 8550 | 99.0 | 0 | 142 | 8550 | 0 | 0 | 50 | 71 | 4275 | TBD | 0 | 75 | 36 | 2138 | $25,200 | 4 |
| Maritza East II (new Unit 8) | 210 | 1,239,171 | 0 | 0 | 99.5 | 0 | 0 | 0 | 0 | 0 | 0 | 71 | 2107 | $18,000 | 0 | 0 | 71 | 2107 | $0 | 0 |
| Maritza East III (4 boilers/STG) | 840 | 9,338,000 | 371 | 15875 | 99.5 | 0 | 371 | 15875 | 0 | 0 | 0 | 371 | 15875 | TBD | 0 | 50 | 186 | 7937 | $33,600 | 4 |
| Varna | 1260 | 2,500,000 | 60 | 7500 | 98.5 | 0 | 60 | 7500 | 0 | 0 | 50 | 30 | 3750 | TBD | 0 | 63 | 23 | 2812 | $50,400 | 4 |
| Bobov Dol | 630 | 800,000 | 1700 | 12000 | 97.0 | 0 | 1700 | 12000 | 0 | 0 | 50 | 850 | 6000 | TBD | 0 | 92 | 142 | 1000 | $25,200 | 4 |
| Ruse | 400 | 500,000 | 60 | 2000 | 98.0 | 0 | 60 | 2000 | 0 | 0 | 50 | 30 | 1000 | TBD | 0 | 88 | 8 | 250 | $16,000 | 4 |
| Total (w/o ME II Unit 8) | 4560 | 25,646,312 | | 80910 | | | | 80910 | | | | | 44002 | $18,000 | | | | 18993 | $158,400 | |
| Average Emissions | | | 495 | | | | 495 | | | | | 274 | | | | | 83.9 | | | |
| Total Short Term (w/ ME II Unit 8 and decomm. 4 old units) | 4170 | 21,236,394 | | | | | | | | | | | | | | | | | | |

Notes:

1. Capital costs are $40/kw for fabric filter particulate control(ref. 26). Operating costs per ref. 26 for OECD plants.
2. Reduction percentages are applied to current levels. For example, 50% reduction from a 99.5% efficient ESP would imply a new 99.75% efficient removal.
3. Maritza East I current particulate removal efficiency does not include the 70% efficient cyclones on the coal dryers but only the 98% efficient ESPs on the boilers. The coal dryer cyclone discharge may be introduced in the boilers and eliminated. This will require further investigation.
4. Particulate emissions are calculated based on all ash exiting the boilers as fly ash.
5. Short term reductions involve potential maintenance efficiency corrections with the possible ESP mods after ESP vendor recommendations. Costs for corrective maintenance should be significantly less than the $40/kw that may be required for baghouse addition.
6. Baghouse control efficiencies are approximately 99.75%.
7. Ruse emissions concentration value of 60 mg/Nm3 is based on the 6/9/92 trip report (Attachment 2, Item 15 of the report). Particulate concentration assumed the same as Varna since similar coals and control equipment are used.
8. Short term power and emissions are based on completing ME II Unit 8 and decommissioning the older 4 units of ME II.
9. ME II Unit 8 completion cost is estimated at $18,000,000 per reference 2. ME II Unit 8 operating costs are listed as zero since they are included in FGD removal costs.

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## TABLE 15–4
## SULFUR DIOXIDE EMISSIONS IMMEDIATE, SHORT TERM AND LONG TERM REDUCTIONS

| | Current | | | | Immediate | | | | | | Short Term Reductions | | | | | Long Term Reductions | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Power MW | Coal Rate TPY | Emiss. mg/Nm3 | TPY | Curr. Effic. % | Red % | Emiss. mg/Nm3 | TPY | Cap. Cost $k | Oper. Cost mills/kwh | Red. % | Emiss. mg/Nm3 | TPY | Cap. Cost $k | Oper. Cost mills/kwh | Red. % | Emiss. mg/Nm3 | TPY | Cap. Cost $1000 | Oper. Cost mills/kwh |
| Maritza East I | 200 | 3,141,711 | 11800 | 100,000 | 0 | 0 | 11800 | 100,000 | 0 | 0 | 0 | 11800 | 100,000 | 0 | 0 | 50 | 5900 | 50,000 | $5,000 | 4 |
| Maritza East II (4 old units) | 600 | 6,649,089 | 17600 | 422,177 | 0 | 0 | 17600 | 422,177 | 0 | 0 | 100 | 0 | 0 | 0 | 0 | 100 | 0 | 0 | $0 | 0 |
| Maritza East II (3 newer units) | 630 | 3,717,512 | 17600 | 277,823 | 0 | 0 | 17600 | 277,823 | 0 | 0 | 0 | 17600 | 277,823 | 0 | 0 | 50 | 8800 | 138,912 | $15,750 | 4 |
| Maritza East II (new Unit 8) | 210 | 1,239,171 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1760 | 9,261 | $18,000 | 10 | 0 | 1760 | 9,261 | $0 | 10 |
| Maritza East III (4 boilers/STG) | 840 | 9,336,000 | 12200 | 600,000 | 0 | 0 | 12200 | 600,000 | 0 | 0 | 0 | 12200 | 600,000 | 0 | 0 | 50 | 6100 | 300,000 | $21,000 | 4 |
| Varna | 1260 | 2,500,000 | 3000 | 90,000 | 0 | 0 | 3000 | 90,000 | 0 | 0 | 0 | 3000 | 90,000 | 0 | 0 | 50 | 1500 | 45,000 | $31,500 | 4 |
| Sobov Dol | 630 | 800,000 | 6000 | 111,262 | 0 | 0 | 6000 | 111,262 | 0 | 0 | 0 | 6000 | 111,262 | 0 | 0 | 50 | 3000 | 55,631 | $15,750 | 4 |
| Ruse | 400 | 500,000 | 3000 | 29,590 | 0 | 0 | 3000 | 29,590 | 0 | 0 | 0 | 3000 | 29,590 | 0 | 0 | 50 | 1500 | 14,795 | $10,000 | 4 |
| Total (w/o ME II Unit 8) | 4580 | 25,646,312 | | 1,630,852 | | | | 1,630,852 | | | | | 1,217,936 | $18,000 | | | | 613,598 | $99,000 | |
| Average Emissions | | | 10171 | | | | 10171 | | | | | 7909 | | | | | 4080 | | | |
| Total Short Term (w/ ME Unit 8 and decomm. 4 old units) | 4170 | 21,236,394 | | | | | | | | | | | | | | | | | | |

Notes:

1. Capital costs are $25/kw for sorbent injection SO2 control ($300/ton sulfur removed or about 4 mills/kwh (ref. 27).
2. Ruse emissions concentration value of 3000 mg/Nm3 is based on the 6/9/92 trip report (Attachment 2, item 15 of the report). SO2 concentration assumed the same as Varna since similar coals are used.
3. SO2 emissions from the ME II plant are divided in proportion to the coal used between the older and the newer units.
4. Short term power and emissions are based on completing ME Unit 8 and decommissioning the older 4 units of ME II and use of lower sulfur coal.
5. Long term reductions are achieved by using sorbent injection FGD controls
6. Long term reductions can also be achieved by burning low sulfur coal or switching to natural gas. These changes are not reflected in this table.
7. ME II Unit 8 completion cost is estimated at $18,000,000 per reference 2. Operating cost of 10 mills/kwh are estimated based on wet lime FGD control costs (ref. 26).
8. ME II Unit 8 removal efficiency based on 90% per reference 2.

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## TABLE 15–5
## NITROGEN OXIDE EMISSIONS IMMEDIATE, SHORT TERM AND LONG TERM REDUCTIONS

| | Current | | | | Immediate | | | | | | Short Term Reductions | | | | | Long Term Reductions | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Power MW | Coal Rate TPY | Emiss. mg/ Nm3 | TPY | Curr. Effic. % | Red % | Emiss. mg/ Nm3 | TPY | Cap. Cost $k | Oper. Cost mills/ kwh | Red. % | Emiss. mg/ Nm3 | TPY | Cap. Cost $k | Oper. Cost mills/ kwh | Red. % | Emiss. mg/ Nm3 | TPY | Cap. Cost $1000 | Oper. Cost mills/ kwh |
| Maritza East I | 200 | 3,141,711 | 1446 | 12,253 | 0 | 0 | 1446 | 12,253 | 0 | 0 | 15 | 1229 | 10,415 | 0 | 0 | 30 | 1012 | 8,577 | $2,000 | 1 |
| Maritza East II (4 old units) | 600 | 5,046,080 | 698 | 24,988 | 0 | 0 | 698 | 24,988 | 0 | 0 | 100 | 0 | 0 | 0 | 0 | 100 | 0 | 0 | $0 | 0 |
| Maritza East II (3 newer units) | 630 | 3,717,512 | 700 | 16,444 | 0 | 0 | 700 | 16,444 | 0 | 0 | 15 | 595 | 13,977 | 0 | 0 | 30 | 490 | 11,511 | $6,300 | 1 |
| Maritza East II (new Unit 8) | 210 | 1,239,171 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 595 | 4659 | $18,000 | 0 | 30 | 416 | 4,659 | $2,100 | 1 |
| Maritza East III (4 boilers/STG) | 840 | 9,338,000 | 1636 | 83,263 | 0 | 0 | 1636 | 83,263 | 0 | 0 | 15 | 1392 | 70,774 | 0 | 0 | 30 | 1146 | 58,284 | $8,400 | 1 |
| Varna | 1260 | 2,500,000 | 1836 | 14,000 | 0 | 0 | 1836 | 14,000 | 0 | 0 | 15 | 1560 | 11,900 | 0 | 0 | 30 | 1285 | 9,800 | $12,600 | 1 |
| Bobov Dol | 630 | 800,000 | 1061 | 10,000 | 0 | 0 | 1061 | 10,000 | 0 | 0 | 15 | 901 | 8,500 | 0 | 0 | 30 | 742 | 7,000 | $6,300 | 1 |
| Ruse | 400 | 500,000 | 3434 | 8,610 | 0 | 0 | 3434 | 8,610 | 0 | 0 | 15 | 2918 | 7,319 | 0 | 0 | 30 | 2403 | 6,027 | $4,000 | 1 |
| Total (w/o ME II Unit 8) | 4560 | 25,646,312 | | 169,558 | | | | 169,558 | | | | | 127,544 | $18,000 | | | | 105,858 | $41,700 | |
| Average Emissions | | | 1544 | | | | 1544 | | | | | 1313 | | | | | 1071 | | | |
| Total Short Term (w/ ME Unit 8 and decomm. 4 old units) | 4170 | 21,236,394 | | | | | | | | | | | | | | | | | | |

Notes:
1. Capital costs are $10/kw for combustion modifications (low–NOx burners) for NOx control and 1 mill/kwh operating cost per reference 26.
2. NOx emissions from the ME II plant are divided in proportion to the coal used between the older and the newer units.
3. Short term power and emissions are based on completing ME Unit 8 and decommissioning the older 4 units of ME II and use of lower sulfur coal.
4. Short term NOx reductions may be achieved by combustion controls/tuning modifications. The actual NOx reduction from these actions are TBD but are in the 10 to 20% range.
5. Long term reductions are achieved by using low–NOx burners. These reductions may be in the 20 to 40% range.
6. Long term reductions can also be achieved by switching to natural gas. These changes are not reflected in this table.
7. ME II Unit 8 completion cost is estimated at $18,000,000 per reference 2.
8. Current NOx emission concentrations have been calculated based on SO2 emission levels that have been adjusted in proportion to the reduced TPY NOx emissions. The current NOx emission concentrations should be confirmed.

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## 16.0 PLANT EMISSION CONTROL, PLANT BETTERMENT/CHANGES PLANT/ MINE ENHANCEMENT MEASURES AND ESTIMATED COSTS

### 16.1 Approach and Plant Evaluation Criteria

The following is a summation of the plant evaluation criteria and approach. The basis for the examination of the plants includes:

- Bechtel Trip Report, March 1992.
- Bechtel Trip Report and Plant Staff Interviews, June 1992.
- Bechtel Trip Report, Plant Walkdown and Plant Staff Interviews, July 1992.
- Bechtel Trip Report, August 1992.

The several plants were evaluated individually and collectively against multiple criteria including age, heat rate, cost/kwh, and capital cost for pollution control equipment. The criteria weighted more heavily were those related to current and recent plant performance. The results of this initial screening evaluation are represented in Table 16-1. From this evaluation a determination was made concerning near term and longer term actions and suggestions concerning plant betterment or rehabilitation. As a result, three levels of action were identified and applied to the respective plants based on their overall condition.



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Table 16-1
Ranking of Plants

| No. (Rank) | Plant Name | Age 2 | Heat Rate 5 | Cost 3 | Total (max) 10 |
|---|---|---|---|---|---|
| 5 | Maritza East 1 | 0 | 3 | 2 | 5 |
| 6 | Maritza East 2 (old units) | 0 | 1 | 1 | 2 |
| 1 | Maritza East 2 (new units) | 2 | 4 | 3 | 9 |
| 3 | Maritza East 3 | 1 | 4 | 2 | 7 |
| 2 | Varna | 1 | 5 | 2 | 8 |
| 4 | Bobov Dol | 1 | 4 | 1 | 6 |
| 4 | Ruse | 1 | 3 | 2 | 6 |



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Immediate Actions

- Shut down the least efficient, most polluting plants that are not necessary to meet Bulgaria's current and future anticipated power requirements. This has been estimated based on reference 22 that predicts demand side management including increasing the cost of energy along with reduction in GDP will reduce energy requirements.

- Improve mine performance with inexpensive housekeeping, minor maintenance, and operational suggestions to support the most efficient power plants that are located at the higher heat content and lower sulfur coal reserve locations.

- Implement minor maintenance, housekeeping fixes to reduce fugitive emissions and increase efficiency at the remaining plants. The following actions can be taken (see attached spread sheet).

- Complete construction of Unit 8 at Maritza East 2 that will have an flue gas desulfurization (FGD) system and shut down the 4 150 MW units at Maritza East 2 as their need is displaced.

- Review the various plants to determine which plants should be based-loaded such as the most efficient, least polluting ones and which ones should be peaking or cycling units.



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Intermediate Term Actions

- Provide least cost pollution controls to the remaining plants, Sorbent Injection (SI) systems at 50% efficiency at the highest sulfur coal plants and possibly 40 - 50% $NO_x$ removal. Implement in stages going from highest sulfur coal burning plants to the lowest, leave space for future reduction via SI, again target the high sulfur coal plants first and do the cleanest coal units last. Table 16-8 has been provided for information on the location of limestone quarries. Before implementation, sources of lime need to be identified.

- In parallel with SI implementation, determine the economics of coal cleaning and possible lower sulfur coal import to reduce coal sulfur content.

- As boiler burners wear out, replace them with low NOx burners with potential reductions of 20-40%. This could be part of routine maintenance costs.

- Optimize/modernize plant controls especially to improve combustion and reduce $NO_x$ (possible 20% reduction).

- Optimize ESP performance to reduce particulate emissions.

- Supply particulate baghouse control equipment to coal drying operations in Maritza East 1 to reduce particulate (if drying is still required) or route the coal drying



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operation exhaust to the boilers. The feasibility of doing this routing needs to be investigated.

Long Term Actions

- Replace conventional pulverized coal fired units with fluidized bed units assuming that Bulgarian coal is still competitive with imported gas or oil. Fluidized bed units are better suited to the combustion of high sulfur and ash coals.

- Consider repowering options at the most polluting and oldest remaining facilities first. This will depend on the availability of natural gas or oil.

- Install baghouses to replace ESP units as they wear out to reduce particulate emissions.

- Install higher efficiency SI equipment for $SO_2$ control at remaining PC plants.

- Implement higher efficiency NOx removal schemes in conjunction with SI control equipment.

The following summarizes plant emission control, plant betterment changes, plant/mine enhancement measures and estimated costs for each of the plants. This information is summarized in Tables 16-1 through 16-7

## 16.2 Maritza East 1

Maritza East 1 consists of several interrelated facilities all of which must continue to operate for at least until the year 2030 according to current plans. The requirement to supply steam to the briquette manufacturing facility provides the rationale for this decision. Given this, the Maritza East 1 plant offers a wide range of plant improvement opportunities. These are summarized in Table 16-2.

For emission control improvements include investigation of the upgrade of the electro static precipitators, and reduction of site fugitive emissions in the near term. Short and long term measures would include the examination of alternatives to the current coal drying operation, provision of low $NO_x$ burners, installation of sorbent injection FGD equipment and possibly repowering of the facility using natural gas.

Plant Betterment suggestions include in the near term the increased scheduling of plant and equipment maintenance. Longer term measures would include upgrading of minor plant equipment, upgrade of plant instruments and controls, and ultimately considering boiler replacement with a fluidized bed unit. Other measures for consideration are conversion of units to gas firing and/or retirement of the unit when the briquette factory ceases to operate.

The coal resource is large enough and can be technically recovered at a justifiable cost. Coal is lignite with marginal quality. Production data and quality characteristics are described in the various reports. Three pits are operating, providing fuel for the three

Maritza East power plant complexes and briquette plant. The mining operations have been independently managed through the power plants. The mining activities are now separated from the power plants, but the three mines' operations are not yet integrated. Plans call for combined management in the future. This should help increase productivity. Reports identify lack of spare parts and mining conditions (wet clay) for low productivity. Other reasons may be the motivation and supervision of labor. The current management style should be changed. More responsibility will have to be given in mine management.

The overburden is relatively soft, no blasting is required. Bucketwheel excavation equipment is used for both, overburden and coal removal. Overburden removal should be done in two phases to save the top soil for reclamation. Refill of the worked areas could be increased to avoid excessive spoilage of fertile land. Apparently the land is raised and becomes more difficult to irrigate. The mined out areas should also be prepared to accept ash.

The plans to go to more conveyor transport would help to minimize the productivity impacts of the extensive and not very flexible rail transport system. Conveyors are easily movable and less area would be occupied by the mining operation. In addition, dust emissions during transfer of coal to belts and from belts to other belts and storage can be better controlled than with trains, the main dust impact being during dumping at the power stations. The control of spillage from belt conveyors is an issue. This may be a house keeping issue, but also an issue of cooperation between the belt crews and the mine workers to first set the belts correctly and secondly to not overload the belts. It's not clear that belt feeders are part of the system to even-out the load.

TABLE 16-2
IMMEDIATE, SHORT TERM, AND LONG TERM PLANT ENVIRONMENTAL STRATEGIES
MARITZA EAST I THERMAL POWER PLANT

| Category | Current Status | Immediate | Short Term | Long Term |
|---|---|---|---|---|
| Plant/Mining Enhancements | See body of report | - Increase availability of excavators from 35-40% to 55%<br>- Reduce 12 hour work shifts to increase productivity<br>- Control spillage from belt conveyors<br>- Reduce road dust with water trucks or oil<br>- Stock adequate spare parts for coal handling equipment | - Remove overburden in 2 phases to save top soil<br>- Use belt conveyors instead of rail<br>- Use larger excavation equipment<br>- Reduce smoking coal by fast turnover of stockpiles, compaction and sealing of coal for long term storage | - Dust collection equipment at transfer points |
| Emission Controls<br>- Particulate<br>- SO2<br>- NOx<br>- CO | - ESP particulate control on boilers<br>- 70% efficient cyclone control on dryers<br>- No SO2 controls<br>- No NOx controls<br>- No CO controls, normal efficiency burners | - Investigate how to upgrade ESP to 99% minimum for all units<br>- Implement better site cleaning to reduce fugitive emissions | - Investigate no drying of coal or alternatively add baghouses after the cyclones<br>- Investigate routing dryer cyclone exhaust to boilers | - Provide low-NOx burners<br>- Install sorbent injection FGD equipment if mature technology<br>- Consider repowering options using natural gas in combined or simple cycle gas turbine installations |

| | | | | |
|---|---|---|---|---|
| **Plant Betterment/ Changes** | See body of report | - Implement more frequent scheduled maintenance in increase equipment and plant availability<br>- Assess electrical system relative to short circuit analysis and system stability | - Upgrade minor plant equip.<br>- Upgrade instruments and controls | - Consider boiler replacement with fluidized bed units<br>- Consider converting all units to gas firing or low sulfur and ash imported coal<br>- Consider shutting down the plant as the need for briquette drying is phased out<br><br>(These betterment options would also reduce air emissions) |

Roads are a dust emitter. Water trucks should be used in mines or roads oiled. The latter could be feasible because no heavy trucks are used to haul coal.

Water accumulation in the pits does not seem to be an issue. Rain can cause slippery roads and belts, and sticky overburden.

Electrically driven mining equipment will have minimum noise pollution. Operation of the train transport system contributes more to noise.

During normal operations, coal is occasionally on fire (smoking) in the storage area. These burns produce gases under reducing oxidizing conditions, including $SO_2$, $H_2S$, CO, $CO_2$, and unburnt coal volatiles. Mitigation would be fast turnover of the stockpiles or compaction and sealing of the coal for long storage.

## 16.3 Maritza East 2

Maritza East 2 is a large station and has several emission-reduction efforts underway and these should be continued. Completion of Unit 8 which could use 70-90% efficiency FGD technology. Refer to Table 16-3 for additional details. Plant improvements, however, are needed and include:

Upgrading or adding to the ESPs or eventually replacing them with baghouses. Additional changes involve use of low-$NO_x$ burners and sorbent injection FGD equipment.

The major plant betterment recommendation is to decommission the four older units due to poor heat rate and their age. Other future changes may include repowering these units with gas. Plant and mine enhancements are similar to the recommendations made for Maritza East 1.

## 16.4 Maritza East 3

Maritza East 3 is a large station with ample space for major changes and additions related to emission control. These are discussed in Table 16-4.

Emission controls recommendations primarily include sorbent injection FGD controls, upgrading ESPs, and the possible addition of low-$NO_x$ burners. Plant betterment changes include the long term potential replacement of the boiler with fluidized bed units. Plant and mine enhancements are similar to the recommendations made for Maritza East 1.

## 16.5 Varna

The Varna Station is a key element in the electricity generation system. Space is limited for plant improvements and thus emission reduction may be accomplished through the use of better fuel. Refer to Table 16-5 for additional details.

Emission controls recommendations include ESP upgrades, sorbent injection FGD control equipment and possibly low-$NO_x$ burners. Plant betterment changes primarily consist of

TABLE 16-3
IMMEDIATE, SHORT TERM, AND LONG TERM PLANT ENVIRONMENTAL STRATEGIES
MARITZA EAST II THERMAL POWER PLANT

| Category | Current Status | Immediate | Short Term | Long Term |
|---|---|---|---|---|
| Plant/Mining Enhancements | See body of report | - Increase availability of excavators from 35-40% to 55%<br>- Reduce 12 hour work shifts to increase productivity<br>- Control spillage from belt conveyors<br>- Reduce road dust with water trucks or oil<br>- Stock adequate spare parts for coal handling equipment | - Remove overburden in 2 phases to save top soil<br>- Use belt conveyors instead of rail<br>- Use larger excavation equipment<br>- Reduce smoking coal by fast turnover of stockpiles, compaction and sealing of coal for long term storage | - Dust collection equipment at transfer points |
| Emission Controls<br>- Particulate<br>- SO2<br>- NOx<br>- CO | - ESP particulate control<br>- No SO2 controls<br>- No NOx controls<br>- No CO controls, normal efficiency burners | - Investigate the upgrade ESP above 99% minimum for all units<br>- Implement better site cleaning to reduce fugitive emissions | - Add to the ESP to improve performance<br>- Complete construction of Unit 8 with FGD equipment (wet lime sys. 70-90% removal efficiency | - Provide low-NOx burners<br>- Install sorbent injection FGD equipment if mature technology<br>- Consider repowering options using natural gas in combined cycle or simple cycle gas turbine installations |

| | | | | |
|---|---|---|---|---|
| Plant Betterment/ Changes | See body of report | - Implement more frequent scheduled maintenance in increase equipment and plant availability<br>- Assess electrical system relative to short circuit analysis and system stability | - Upgrade minor plant equip.<br>- Decommission the four 150 MW units due to age and poor heat rate (13,807 Btu/kWh vs 10,931 Btu/kWh for the 210 MW units) as more efficient units with reduced emissions come on line<br>- Improve boiler circulation to reduce tube overheating in the lower part of the furnace<br>- Upgrade instruments and controls | - Consider boiler replacement with fluidized bed units<br>- Consider converting all units to gas firing or low sulfur and ash imported coal |

boiler rehabilitation and upgrading activities. The main plant enhancement recommendations involving going ahead with the current port deepening and considering lower sulfur coal imports.

## 16.6 Bobov Dol Thermal Power Plant

The Bobov Dol Plant is limited by fuel availability and emission reduction potential. Repowering with natural gas and/or some form of emission reduction are possibilities. Refer to Table 16-6 for additional details. Emission controls recommendations include upgrading the ESPs, provide low-$NO_x$ burners and installation of sorbent injection FGD equipment. Plant betterment changes include the installation of fluidized bed units or gas firing or imported low sulfur coal.

Plant/Mine Enhancements. The coal from the Bobov Dol mine is difficult to mine; the seams slope and even outcrop as vertical veins. Little surface mining is performed. The main production comes from underground mines. The coal seems gassy (methane) and mining conditions are difficult to severe with very little room for mechanization. Manual mining seems to be the norm. Underground mining has the least impact on the surface compared to large openings and over burden removal operations in case of surface mining. Subsidence and disposal of rock and mine drainage are the main issues. Mine ventilation is an important safety issue with shafts and slopes providing the entries and exhausts. The impact on the environment could be locally significant with dust and methane emissions. It's not clear if they control these emissions. Transport should have a minimal impact. Most coal gathering is done underground. The surface transport is by train. Transfer points



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TABLE 16-4
IMMEDIATE, SHORT TERM, AND LONG TERM PLANT ENVIRONMENTAL STRATEGIES
MARITZA EAST III THERMAL POWER PLANT

| Category | Current Status | Immediate | Short Term | Long Term |
|---|---|---|---|---|
| Plant/Mining Enhancements | See body of report | - Increase availability of excavators from 35-40% to 55%<br>- Reduce 12 hour work shifts to increase productivity<br>- Control spillage from belt conveyors<br>- Reduce road dust with water trucks or oil<br>- Stock adequate spare parts for coal handling equipment | - Remove overburden in 2 phases to save top soil<br>- Use belt conveyors instead of rail<br>- Use larger excavation equipment<br>- Reduce smoking coal by fast turnover of stockpiles, compaction and sealing of coal for long term storage | - Dust collection equipment at transfer points |
| Emission Controls<br>- Particulate<br>- SO2<br>- NOx<br>- CO | - ESP particulate control (99.5% efficiency)<br>- No SO2 controls<br>- No NOx controls<br>- No CO controls, normal efficiency burners | - Implement better site cleaning to reduce fugitive emissions | - Add to the ESP to improve performance | - Provide low-NOx burners<br>- Install sorbent injection FGD equipment if mature technology<br>- Consider repowering options using natural gas in combined cycle or simple cycle gas turbine installations |

| | | | | |
|---|---|---|---|---|
| Plant Betterment/ Changes | See body of report | - Implement more frequent scheduled maintenance in increase equipment and plant availability<br>- Assess electrical system relative to short circuit analysis and system stability<br>- Assess the boilers' slagging problems and determine the appropriate deslagging measures | - Upgrade coal crushing capacity to increase unit power to 210 MW from the current 200 MW<br>- Upgrade minor plant equip.<br>- Upgrade instruments and controls | - Consider boiler replacement with fluidized bed units<br>- Consider converting all units to gas firing or low sulfur and ash imported coal |

TABLE 16-5
IMMEDIATE, SHORT TERM, AND LONG TERM PLANT ENVIRONMENTAL STRATEGIES
VARNA THERMAL POWER PLANT

| Category | Current Status | Immediate | Short Term | Long Term |
|---|---|---|---|---|
| Plant/Mining Enhancements | Imported coal- 10,000 T ships from the Ukraine | Increase reliability of coal supplies | Deepening access channel to allow larger ships- 50,000 T capacity | - Import of lower sulfur, ash coal<br>- Dust collection equipment at transfer points |
| Emission Controls<br>- Particulate<br>- SO2<br>- NOx<br>- CO | - ESP particulate control<br>- No SO2 controls<br>- No NOx controls<br>- No CO controls, normal efficiency burners | - Investigate how to upgrade ESP performance to 99% minimum for all units<br>- Implement better site cleaning to reduce fugitive emissions | - Provide new ESPs for older units | - Provide low-NOx burners that also can use gas to assist in more complete coal combustion<br>- Install sorbent injection FGD equipment if mature technology<br>- Consider repowering options using natural gas in combined cycle gas turbine installation |
| Plant Betterment/ Changes | See body of report | - Implement more frequent scheduled maintenance in increase equipment and plant availability<br>- Assess electrical system relative to short circuit analysis and system stability | - Evaluate if older units should be decommissioned based on condition, heat rate<br>- Upgrade instruments and controls | - Boiler rehabilitation with high temp. steels, better controls, high quality switchgear |

may be dust sources. Even though the coal has a high moisture content it is surface dry. More so, if exposed to air, the coal slacks and falls apart into dust. Spontaneous combustion could be a concern if stored in open air for a longer period; however, the low production rate seems to avoid any significant storage requirements.

There are questions about the continuation of the underground mining operation. Major investments would be required to bring the mine(s) to productivity and health and safety standards. Even at present, the cost is not justified. A controlled closure over a certain period of time would be the best solution. Retraining of the miners is an issue.

## 16.7 Ruse Thermal Power Plant

The Ruse Thermal Plant like the Varna Station could realize some emission improvement through the use of higher quality fuel. Also, the Ruse station could be repowered using natural gas. Refer to Table 16-7 for additional details. Emission controls recommendations include upgrading the ESPs, providing low $NO_x$ burners, and eventually installing sorbent injection FGD equipment. Plant betterment changes include eventually replacing the boilers with fluidized bed units or consideration of converting them to gas-fired units. The main recommendations for plant/mine enhancements involve going ahead with the current port deepening and considering lower sulfur coal imports. Coal is imported from the Ukraine. The coal storage should be increased to assure operation and availability. In addition, low sulfur coal supplies should be explored.

TABLE 16-6
IMMEDIATE, SHORT TERM, AND LONG TERM PLANT ENVIRONMENTAL STRATEGIES
BOBOV DOL THERMAL POWER PLANT

| Category | Current Status | Immediate | Short Term | Long Term |
|---|---|---|---|---|
| Plant/Mining Enhancements | See body of report | Supply an alternate source of coal with lower sulfur and ash that is less expensive to blend with the currently mined coal | Phased closing of the current mining site | - Import of lower sulfur, ash coal<br>- Dust collection equipment at transfer points |
| Emission Controls<br>- Particulate<br>- SO2<br>- NOx<br>- CO | - ESP particulate control<br>- No SO2 controls<br>- No NOx controls<br>- No CO controls, normal efficiency burners | - Investigate how to upgrade ESP to 99% minimum for all units<br>- Implement better site cleaning to reduce fugitive emissions | - Convert two of the three units to burn either imported low sulfur and ash coal or natural gas (NG) | - Provide low-NOx burners<br>- Install sorbent injection FGD equipment if mature technology<br>- Consider repowering options using natural in combined cycle gas turbine installations |
| Plant Betterment/ Changes | See body of report | - Implement more frequent scheduled maintenance in increase equipment and plant availability<br>- Assess electrical system relative to short circuit analysis and system stability | - Investigate replacement of pulverizers with units better suited to the high ash content of the local coal<br>- Upgrade instruments and controls | - Consider boiler replacement with a fluidized bed unit<br>- Consider converting all three units to gas or imported coal firing |

TABLE 16-7
IMMEDIATE, SHORT TERM, AND LONG TERM PLANT ENVIRONMENTAL STRATEGIES
RUSE THERMAL POWER PLANT

| Category | Current Status | Immediate | Short Term | Long Term |
|---|---|---|---|---|
| Plant/Mining Enhancements | Imported coal by ship from the Ukraine | Assure adequate coal storage to get through the winter- about 400,000 T of coal | Replace/upgrade the coal conveying system, including conveyor belts | - Import lower sulfur, ash coal<br>- Dust collection equipment at transfer points |
| Emission Controls<br>- Particulate<br>- SO2<br>- NOx<br>- CO | - ESP particulate control<br>- No SO2 controls<br>- No NOx controls<br>- No CO controls, normal efficiency burners | - Investigate how to upgrade ESP to 99% minimum for all units<br>- Implement better site cleaning to reduce fugitive emissions | - Convert the units to burn either imported low sulfur and ash coal or natural gas (NG) or be dual fuel capable | - Provide low-NOx burners<br>- Install sorbent injection FGD equipment if mature technology<br>- Consider repowering options using natural gas in combined cycle gas turbine installations |
| Plant Betterment/ Changes | See body of report | - Implement more frequent scheduled maintenance in increase equipment and plant availability<br>- Assess electrical system relative to short circuit analysis and system stability | - Upgrade mechanical and electrical equip. as approp.- valves and cooling system<br>- Upgrade instruments and controls | - Consider boiler replacement with a fluidized bed units<br>- Consider converting all four units to gas firing |

Table 16-8
Location of Limestone Quarries in Relation to
Selected Thermal Power Plants

| | | $CaCO_3$ Purity | Deposits | Annual Capacity | Varna | Ruse | Bobov Dol | Maritza East | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | 1 | 2 | 3 |
| Name | Region | % | m/u t | m/u t | | | | | | |
| 1. Lujlia Kata | Varna | 95.8 | 45 | 1.3 | • | | | | | |
| 2. Second Part | Varna | 55.0 | 230 | 1.2 | • | | | | | |
| 3. Suerhuo Pole | Varna | 90.8 | 165 | | • | | | | | |
| 4. Second Part | Varna | 55.0 | 808 | No | • | | | | | |
| 5. Temelkovo | Bobov Dol | 79.4 | 102 | 0.26 | | | • | | | |
| 6. Zemen | Bobov Dol | 94.0 | 25 | 0.25 | | | • | | | |
| 7. Kozjak | Bobov Dol | 54.7 | 27 | 0.63 | | | • | | | |
| 8. Bogdanovo | Near Burgas | 54.5 | 109 | | • | | | • | • | • |
| 9. Jur-deret | Maritza | 95.8 | 59 | 0.40 | | | | | | |
| 10. Bratja Kupchivi | Maritza | 93.0 | 88 | | | | | • | • | • |

## 17.0 EMISSION SOURCE COMPARISON

One of the issues considered in this study was the extent to which emissions from power plants compare with other sources of air pollution and whether emissions from low-level sources pose more serious health and environmental risks. To address this subject

- current and project emissions from power plants were determined,
- ambient air quality conditions for selected air basins in Bulgaria were examined,
- other non-power stationary sources of air emissions were identified as contributors to emission levels within selected air basins,
- other non-power mobile sources of air emissions as well as potential area sources of emissions were identified and assessed for their relative contribution to emission levels within selected air basins,
- a qualitative assessment of the relative significance of non-power sources of emissions to health and environmental risk was made.

### 17.1 Fossil-Fired Power Plant Emissions

Tables 15-5, 6, and 7 identify the current and projected emissions for the plants examined in this study. Included as well are projected emissions from these plants. As noted in

section 16 several plant modifications and changes have been suggested and these are also noted in Tables 15-5, 6, and 7 for reference. This includes measures such as fuel switching to natural gas, using lower sulfur coal or the installation of emission controls.

## 17.2 Ambient Air Quality and Selected Air Basins

Ambient air quality varies considerably in Bulgaria. Table 17-2 identifies average annual ambient air pollution levels in selected areas of Bulgaria as well as the current ambient air quality standard (AAQS) for each pollutant. For the areas identified both power plants and non-power plant air emission sources are contributing to air pollution levels. The criteria used to identify these high air pollution areas are a combination of topography, average wind speed, temperature inversion potential and net measurement of emissions from point and air emissions sources. Again, both power and non-power air emission sources are contributing to this pattern. For example those areas where the most intensive air pollution occurs are those with other major non-power sources. These include Ruse and Varna-Devnya. In the Varna-Devnya area, besides the Varna station there is a PVC plant, cement plant, and a fertilizer plant all of which contribute to higher air pollution levels. The relatively low sulfur coal currently used at Varna maintain the overall $SO_2$ levels reasonably low from an area-wide standpoint within the current AAQS.

In the Ruse area, besides the Ruse station, there is an oil refinery, ferrous metal plant, plastics plant and a paint plant which combined contribute to the prior air quality.



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Table 17-1

Average Annual Ambient Air Pollution Levels in Selected Spots, 1989-1990

| Pollutant | Standard ($ug/m^3$) | Asenov-grad | Vratsa | Devnya | Dimitrov-grad | Kurdzhali | Plovdiv | Ruse | Panagiu-rishte | Sredno-gorie |
|---|---|---|---|---|---|---|---|---|---|---|
| 1. Dust | 150.0 | 270.0 | 160.0 | 350.0 | 530.0 | 310.0 | 280.0 | 300.0 | 320.0 | 400.0 |
| 2. $SO_2$ | 80.0 | 485.0 | 58.8 | 28.0 | 119.2 | 102.5 | 305.8 | 32.1 | 349.7 | 440.0 |
| 3. $NO_2$ | 50.0 | 15.3 | 22.9 | 8.6 | 10.4 | -- | 31.0 | 29.2 | -- | -- |
| 4. $H_2S$ | 8.0 | -- | 9.8 | 22.9 | 20.8 | -- | -- | 5.9 | -- | -- |
| 5. P | 2.0 | 2.6 | 0.3 | 0.3 | 0.7 | 1.5 | 1.0 | 0.4 | 0.5 | 0.4 |
| 6. $NH_3$ | 40.0 | -- | 194.5 | 49.4 | -- | -- | -- | -- | -- | -- |
| 7. $Cl_2$ | 30.0 | -- | -- | 7.5 | -- | -- | -- | -- | -- | -- |
| 8. HF | 5.0 | -- | -- | 13.5 | 16.0 | -- | -- | -- | -- | -- |
| 9. $H_2SO_4$ | 100.0 | -- | (1.5xstd) | 100.6 | -- | 187.0 | -- | -- | 294.9 | 300.0 |
| 10. As | 3.0 | -- | -- | -- | -- | -- | -- | -- | 1.4 | 1.1 |

Like Varna, the Ruse plant uses relatively low sulfur coal and thus the $SO_2$ levels are within the current AAQS.

Bobov-Dol and the Maritza East vicinity are areas of intensive air pollution but the problem. However, while important, the levels are less than elsewhere in Bulgaria, particularly where large scale industrial and chemical plants are juxtaposed in poorly ventilated valleys and air basins. The air quality of these areas plus the Sofia area suffer from high concentrations of population, operation of district heating plants, home heating using charcoal briquettes, and motor vehicles without emission controls.

## 17.3 Assessment

Existing and proposed controlled emissions from thermal power plants are compared with non-power plant point sources in Table 17-2. Besides industrial point sources are non-point sources such as motor vehicles, fugitive emissions and related non-point emission sources. However, only published non-power plant point source emissions are shown. The results are:

1. When controlled, the thermal power plant emissions are substantially less than non-power plant sources.

2. Selected non-power industrial emission sources comprise a major proportion of emissions, in selected areas such as Varna and Ruse. These sources include chemical plants, cement plants, refineries, PVC plants and paint manufacture.

Table 17-2

Emissions Comparison

| Power Plant | Total Plant Emissions ($SO_2$, Particulate, $NO_x$) | | | | Proximal Emissions Sources | |
|---|---|---|---|---|---|---|
| | Current TPY | Proposed TPY | Change | | Source(s) | Amount TPY |
| | | | Amount TPY | Percent | | |
| ME-1 | 134,245 | 61,326 | 72,919 | 54 | 1. Fertilizer Plant (Dimitovgrad)<br>2. Cement Plant (Dimitovgrad) | N/A |
| ME-2 | 762,975 | 168,588 | 594,387 | 78 | Same as ME-1 | N/A |
| ME-3 | 699,138 | 366,221 | 332,917 | 48 | Same as ME-1 | N/A |
| Bobov Dol | 133,262 | 63,631 | 69,631 | 52 | 1. Ferrous Metallurgy (Pernik)<br>2. Cement Plant (Pernik) | N/A |
| Varna | 111,500 | 57,612 | 53,888 | 48 | 1. Power Plant (Devnya)<br>2. Cement Plant<br>3. Soda Plant<br>4. Fertilizer Plant<br>5. PVC Plant<br>TOTAL | 22,170<br>2,385<br>4,070<br>2,906<br>138<br>31,699 |
| Ruse | 40,200 | 21,072 | 19,128 | 48 | 1. Oil Refinery | 948 |

3. Comparative risk between controlled thermal power plant power and non-thermal power plant sources is lowest for the Ruse and Varna areas. These areas have comparatively higher emissions from non-thermal power plant sources than from thermal power plant sources.

For the Maritza East area, the overall risk improvement is greatest with the improvement of emission controls because of a general absence of other nearby stationary emission sources.

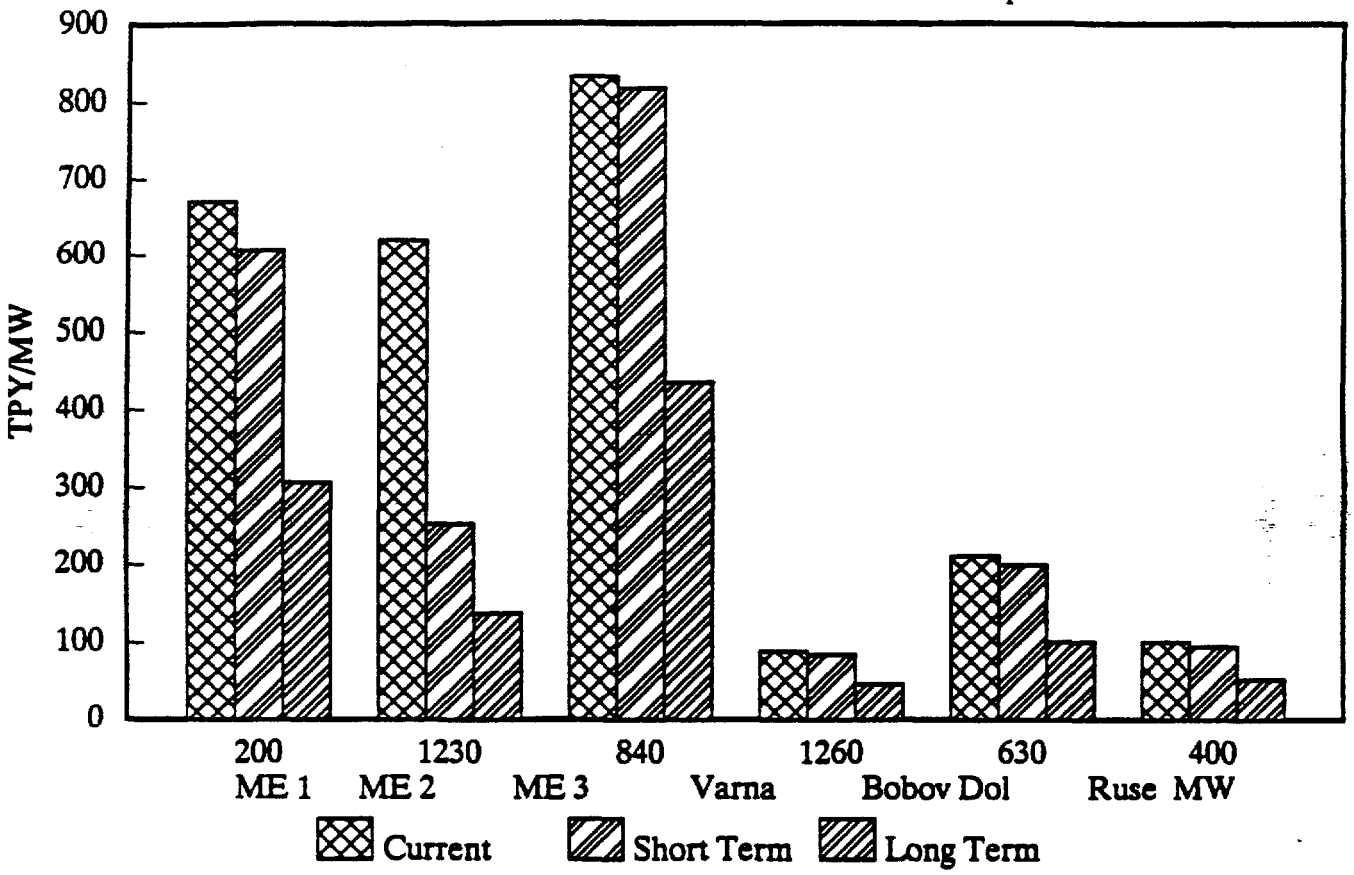
4. Highest environmental risk associated with atmospheric emissions will continue to be highest in urban areas because of motor vehicle emissions, district heating plants, and the use of charcoal briquettes for home heating, and in industrial areas where chemical plants, cement plants, refineries and related industrial sources lack sufficient emission controls.

5. Control of thermal power plant emission to meet the 1995 emission levels will reduce the overall risk both in the areas within which they are situated, but in the nation as a whole. See the following charts showing the reduction in power plant emissions.

Figure 17-1 shows a comparison of current emissions on a tons per year (TPY) per MW power output basis. The plants range from Maritza East 3 with the highest totals and to the Varna plant with the lowest. Figure 17-1 also shows how these emissions can be reduced in the short term and long term. Long term emissions are reduced from 48% for Maritza East III, Varna, and Ruse up to 78% for Maritza East II.

# Figure 17–1

Power Plant Current and Future Emission Comparisons




Emissions include SO2, NOx, and TSP only.



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## 18.0 POWER INDUSTRY ENVIRONMENTAL ISSUES, MITIGATION MEASURES AND ECONOMIC ASSESSMENT

The following is a discussion of environmental regulatory trends, drawing heavily from U.S. experience. The areas covered are:

- Acid Rain and Control of $SO_2$ and $NO_x$ Emissions
- Lower Atmospheric Ozone
- Air Toxics
- Global Warming from the Greenhouse Effect
- Water Pollution Control and Thermal Effects
- Solid Waste Management and Disposal
- Electromagnetic Fields

These trends are likely to indicate the direction of Bulgarian environmental regulations and will be critical to electric power sector. For each is provided information on regulatory development, pollution control technology costs, and policy issues.

## 18.1 Acid Rain and Control of $SO_2$ and $NO_x$ Emissions

### Background and Regulatory Development

Emissions of $SO_2$ and $NO_x$, when subjected to chemical processes in the atmosphere, have resulted in increased deposition of wet and dry acidic material in downwind areas. The effects are claimed to cause damage to forest trees, high acidity and "death" of lakes, fish kills during spring runoff, damage to commercial crops, and even corrosion of structural materials. Legislative attempts are underway to mandate retrofit of existing stationary emission sources to achieve significant near-term reductions, with emphasis on $SO_2$. This includes the Amended Clean Air Act of 1990 in the United States as well as the EEC Directive 88/609. Common to both is the intent to limit $SO_2$ and $NO_x$ emissions within the general context of emission ceilings and emission reduction targets.

### Pollution Control Technology Costs

Proven technology is available to remove over 90 percent of the $SO_2$ from conventional coal-fired plants with processes such as advanced wet limestone flue gas desulfurization.

Capital installation costs for FGD equipment range widely from $50/KW to $300/KW depending on removal efficiency, fuel, and site-specific factors. Operating technology to reduce $NO_x$ emissions is under active demonstration at this time, and integrated $SO_2$ and $NO_x$ control technologies are in the early development stage. Because of the increased trend toward competition and the uncertainties of retrospective regulatory reviews, most

utility and industrial operators are very reluctant to retrofit their plants for emission reduction unless forced to do so.

Particulate control technology costs such as high efficiency (99.5% minimum) baghouses are in the $40/kw range. $NO_x$ control costs are in the range of $10/kw to $50/kw ranging from low $NO_x$ burners to SCRs.

Policy Issues

Several other factors affect this issue. The use of coal is strategically important to the U.S. and Bulgaria, because it is the only way to limit resurging dependence on foreign oil so long as the nuclear option is stalled in these countries. Demonstration and deployment of clean coal technologies are needed.

## 18.2 Lower Atmospheric Ozone

Background and Regulatory Development

In the lower atmosphere, ozone is formed by photochemical reactions involving $NO_x$ and volatile organic compounds (VOCs). VOCs are a class of organic gases emitted from mobile sources (i.e., cars and trucks), organic solvents, and industrial facilities, as well as from natural sources (e.g., trees).

In the United States, ozone non-attainment is fairly commonplace and typically occurs in regions having heavy usage of motor vehicles. However, it is also evident that stationary sources contribute; roughly half of the $NO_x$ emitted in the U.S. is generated in ozone non-attainment areas.

Ozone's short-term health effects are well recognized, and ozone is also suspected of contributing to the development of chronic lung diseases. High levels of ozone have also been blamed for low crop yields and declining tree growth.

Pollution Control Technology Costs

Lower atmosphere ozone can be controlled by controlling VOC and $NO_x$ emissions. Controls of VOCs are not relevant to power plants, and $NO_x$ controls are discussed briefly in the previous section.

Policy Issues

The scientific understanding of ozone formation - including sources of VOCs, chemistry of ozone formation, meteorological factors, correlating ozone concentrations with VOC and $NO_x$ levels - is incomplete. The scientific community is also debating the severity of health effects due to elevated ozone levels. However, certain adverse effects are well recognized. Therefore, the need to lower ozone concentrations in non-attainment areas remains a priority in those locales.

Siting new power plants in areas having elevated ozone concentrations is problematic. Utilities having existing power plants in such areas need to anticipate the onset of new regulatory controls on $NO_x$ emissions.

## 18.3 Air Toxics

### Background and Regulatory Development

"Air toxics" are hazardous air pollutants to which no ambient air quality standard is applicable and which cause or contribute to air pollution that may reasonably be anticipated to result in an increase in mortality and/or serious irreversible, or incapacitating reversible, illness.

The health and environmental risks associated with these pollutant chemicals are difficult to assess; however, the U.S. Environmental Protection Agency (EPA) has estimated that facilities in 37 states - primarily in those states along the Atlantic Gulf and Pacific coats - are associated with toxic releases that pose high individual cancer risks. Therefore, provisions to reduce "air toxics" emissions are key elements of the U.S. Clean Air Act (CAA) amendments promulgated in 1990.

Sources of air toxics emissions include utility boilers. However, EPA can regulate utility-related air toxics emission only if the agency finds regulation is appropriate and necessary, after a 3-year study of the health hazards. A comprehensive risk assessment will be vital

and essential for rulemaking, as health risk due to a pollutant is the basis for EPA's setting of regulatory standards.

Pollution Control Technology Costs

Energy-related sources of air toxics emissions include oil- and coal-fired utility boilers, petroleum refineries, and exploration and production operations for oil and gas. Although many of the control technologies for conventional pollutants also remove air toxics, additional controls will be required to control some toxic emission constituents.

In the U.S., control technology guidelines are being prepared; this will help to determine performance of various emission control devices in removing trace chemicals. This capability is needed if a risk assessment supports the need for controls at a given power plant. These guidelines will provide emission factor estimates and insights into the mechanisms of chemical removal, and for developing design criteria for control technology. For example, the role of temperature, electrostatic precipitator size and performance, and the concentration and form of trace elements in the coal will be discussed (if known) in terms of their impact on emissions and removal.

Policy Issues

There are good reasons why power plant emissions are not the primary focus of the new Clean Air Act Amendments' air toxics provisions. EPA studies show that those emissions of potential cancer-causing constituents pose small risks (less than one additional cancer



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incident per year in the United States) for the general population. EPA has stated, however, that this value is a rough estimate containing considerable uncertainty. Its studies included arsenic, selenium, hexavalent chromium, cadmium, formaldehyde, and radionuclides emitted from coal- and oil-fired boilers. An industry review of the study suggests that the estimate is conservative and that the resolution of uncertainties may lead to a lower estimate.

However, the Bulgarian utility industry will be well advised to follow research and prepare cost-effective control-technology strategy for the treatment and removal of air toxics pollutants, for application at the time of need should it be required in the future.

## 18.4 Global Warming from the Greenhouse Effect

### Background and Regulatory Development

Increased levels of "greenhouse" gases in the atmosphere since the onset of the industrial revolution have coincided with an increase in average global temperature of 0.5-0.7 °C (0.9-1.3 °F) over the last century. 1989 was the warmest year on record for the earth as a whole.

Greenhouse gases trap infrared energy which would otherwise radiate into space. Increased levels of greenhouse has emissions in the future are expected to contribute to an accelerated global warming effect. The extent, timing, and consequences of this global warming are not yet well understood, but the potential consequences are far-reaching.



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The key greenhouse gases, their current relative levels of contribution to the warming phenomenon, and their primary sources as estimated in recent published reports are listed below:

- Carbon dioxide ($CO_2$): 50 percent, from burning of fossil fuels and deforestation

- Methane ($CH_4$): 20 percent, from coal and petroleum production, wetlands, and animal and insect digestion

- Chlorofluorocarbons (CFCs): 15 percent, from insulating foams and refrigerants

- Nitrous oxides ($N_2O$): 10 percent, from burning of fossil fuels, fertilizers, and other sources

- Lower atmosphere ozone ($O_3$): 5 percent, from atmospheric photochemical reactions

Prior to the industrial revolution, the atmospheric $CO_2$ concentration is estimated to have been approximately 295 ppm. This concentration had increased to 335 ppm by 1980 and is postulated to double during the next century. Methane concentrations are climbing at a 1 percent annual rate and have increased 11 percent over the last decade. Recent analysis indicate methane in the atmosphere may have doubled in the last 2000 years.

Recent climatic phenomena have raised the public and political level of awareness of the greenhouse effect. The lack of rain in the central U.S. summer, 1989 being the warmest

year on record, and the 1980s being the warmest decade in a century have all contributed to this increasing concern that perhaps a serious problem exists. Much of the scientific community is convinced that the issue is very real and that $CO_2$ is a major contributor.

Pollution Control Technology Costs

The Electric Power Research Institute (EPRI) in the United State has started to examine the impact of removing $CO_2$ from coal burning facilities and has found it to be very expensive. They are also examining the concept of a coal refinery which would produce multiple products from coal, including $CO_2$. Disposal of large quantities of $CO_2$ is a major problem, with pumping to the deep oceans being suggested.

Policy Issues

If current studies confirm that long-term preventive measures are necessary, the potential courses of action include:

- Revitalization of the nuclear power option; revitalized effort to develop cost-effective renewal energy sources

- Reevaluation of the environmental restriction on the development of new hydroelectric dams and long-distance transmission lines

- Shift in fossil-fueled power plants to higher efficiency and cleaner fuels such as natural gas

- Shift towards electric-powered vehicles and mass transportation methods

- Generation and use of alternate transportation fuels such as hydrogen

- Increased efforts in energy conservation

If severe effects are unavoidable, other remedial measures may become necessary, including substantial civil projects in coastal areas to mitigate the effects of rising sea levels, and water supply or irrigation projects to adjust for changes in climate and precipitation patterns.

Individual countries should not be expected to take unilateral courses of action which would foreclose the additional use of fossil fuels. Any such unilateral action could impose significant economic penalties on those countries without making a significant contribution to solving the global warming problem.

## 18.5 Water Pollution Control and Thermal Effects

### Background and Regulatory Development

The issue of water pollution control in relation to a wide range of future energy projects and technologies is fundamentally less complex than the two air quality issues identified and

discussed above. Broadly, water pollution control is not a major power plant design and planning issue. Where it becomes important lies in the following areas including:

- Water availability, use, and recycle
- Zero discharge issues
- Thermal impact on the aquatic environment
- Water treatment and control associated with $NO_x$ emission control strategies
- Water treatment and control associated with flue gas desulfurization treatment and control methods

In all of these issues we believe it is essential to consider ways in which we can enhance plant planning and environmental performance in the several areas of water quality management and wastewater treatment and control. Certain energy power supply alternatives have a higher potential than others to contribute water quality control problems. Central to the examination of any energy planning options are the measurement, analysis, and control of unique and special water quality contaminants which can impact surface and groundwater quality.



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## Pollution Control Technology Costs

Pollution control processes and technology as practiced and applied to controlling water pollution due to power plant operations are proven and well documented. In addition, research and pilot scale work is continuing for development of innovative techniques to improve the state-of-the-art technology.

Water pollution controls amounting to compliance with regulatory requirements include conventional treatment methods covering physical, chemical, and biological treatment. As previously stated, in recent times much emphasis has been given to controlling at the source to eliminate/reduce the pollutant stream as generated, in order to achieve such controls, process modifications are being investigated which would ultimately make it feasible to achieve or approach zero discharge criteria. The control strategy employed should also take into account maintenance of beneficial uses of the receiving water for downstream users to the maximum extent possible.

Physical treatment of effluent includes the conventional sedimentation process, aided or unaided by addition of chemicals, as well as thickening with subsequent treatment and disposal of resulting sludge, and use of evaporation ponds, lined or unlined, to prevent groundwater contamination. Chemical treatment includes chemical feed for stabilization, precipitation, and/or adsorption of selected and regulated constituents in the process wastewater from the plant to achieve regulatory compliance. Biological treatment includes treatment of sanitary wastewater and/or mixed wastewater by aerobic or anaerobic

biological treatment processes (like activated sludge, bio-disc, lagoons, etc.) as warranted to comply with the applicable regulations.

In specific cases, natural or created wetlands have been used for control of water pollution caused by power plant or other sources, with favorable results.

Policy Issues

The policy issue is that of greatest impact on U.S. water pollution control is the feasibility of imposing the "zero discharge" concept. If enforcement becomes mandatory from the regulatory standpoint, it would be expensive to the specific plant in particular and the utility industry in general. As this issue is pursued, the utility industry will be well advised to keep up with research and investigative efforts to develop cost-effective mitigation and control measures and innovative recycling and reuse option for process water to maximize water usage, particularly as regulations move toward the "zero discharge" concept.

## 18.6 Solid Waste Management and Disposal

Background and Regulatory Development

The issue of solid waste management and control relates primarily to bottom ash and fly ash disposal, flud gas desulfurization waste, $NO_x$ control additives and waste, boiler slag, and solid wastes associated with several of the clean coal combustion technologies. Each of these solid waste products has its own unique qualities from the U.S. environmental

regulatory standpoint. Most of these waste constituents are handled as solid wastes according to normal conventions of solid waste management. Some may be viewed as hazardous waste or if not strictly hazardous waste, then handled in a manner which precludes their contamination of surface and groundwater. For example, cadmium and arsenic are typically found in ash and sludge, and these are normally considered hazardous wastes.

## Pollution Control Technology Costs

Techniques and methods associated with solid waste disposal have been developed which permit full protection to the environment. As is the case with water pollution control, we in the U.S. are seeing the need to provide a pollution control method which, for all practical proposes constitutes a "zero discharge" design concept. This typically includes a design concept which protects surface and groundwater through the installation of an impoundment with double liners, a leachate collection system, and groundwater monitoring wells above and below the impoundment. In some cases, an ambient air quality monitoring program may be necessary if the solid waste landfill operation is capable of releasing emissions off-site. Incineration as a form of solid waste disposal may be practiced, only in the applicable air quality regulations allow such practices at the location.

## Policy Issues

Policies and/or resulting regulations addressing the questions of hazardous waste are not well defined in the context of solid waste disposal; as discussed earlier, the end products of

such disposal (by either landfill or incineration), which are not airborne, are not well defined as they undergo chemical changes and may have to be characterized on a case-by-case basis, before categorizing them under hazardous wastes. This is also complicated by the fact that research is ongoing.

It may be suggested that the relevant policy issues affecting water and air quality as well as hazardous waste (including air toxics) be closely followed in order to develop an effective management plan for the solid waste disposal for the power plant to be designed and operated at any location and postulated plans be discussed, if possible, with applicable regulatory authorities to receive timely and adequate guidance.

## 18.7 Electromagnetic Fields

### Background and Regulatory Development

The possibility that exposure to electromagnetic fields (EMFs) may cause adverse health effects is emerging as an issue that may impact the electric utility industry. Although at present there is no scientifically established cause and effect relationship between EMF and adverse health effects, an international research program is now under way. This research encompasses epidemiologic studies, microbiological investigations, etc.

In the U.S., the Department of Energy (DOE) has been sponsoring laboratory research for many years, and the National Cancer Institute (NCI) is conducting a major study of childhood leukemia which includes EMF as one of the risk factors. Several states are also

pursuing this issue, and industry - principally through the Electric Power Research Institute and the Institute of Electrical and Electronics Engineers - has programs under way.

Pollution Control Technology Costs

In view of the fact that there is no scientific basis presently for setting numerical limits on power frequency electromagnetic fields, control technologies have not been developed. However, strategies such as remote routing of high-tension lines and undergrounding of power cables in populated areas can be employed to minimize the risk. Risk management strategies, such as placement of EMF measuring instrumentation near transmission equipment in populated areas may be helpful to help allay public concern.

Policy Issues

The potential public health risk of EMF obviously is relevant for all power supply alternatives; however, the greatest impacts would result from importation of power due to the need for new long-distance transmission lines. Growing public awareness and education in this matter will also be instrumental in policy-making regarding this issue. As this issue unfolds, utilities must keep abreast of ongoing research and regulatory developments.

## 19.0 PRELIMINARY $NO_X$ AND $SO_2$ STRATEGY

The following outlines a preliminary $NO_x$ and $SO_2$ control strategy for the thermal power plants studied. In addition, this strategy considers a collective $NO_x$ and $SO_2$ control strategy for the NEC as a whole. Immediate, intermediate, and long-term considerations and associated actions or decisions are part of this strategy. These were developed in Section 16 on a plant-specific basis and are summarized in the following.

### 19.1 Plant-Specific Measures

Plant-specific controls, recommendations and preliminary costs are identified in Section 16. The design and installation costs of these control methods will be specified. Included will be electricity costs, raw materials and additives, operator training and solid and liquid waste disposal costs. Finally, implementation plan recommendations will be offered in terms of the recommended training of these actions. Near-term and long-term strategy issues will be identified. These are summarized in Tables 16-1 and 16-6 and are summarized below.

<u>Maritza East 1</u>

The mining operation should be upgraded. Coal drying should be eliminated or baghouse or other additional controls added to drying operation. These are short term actions. In the long term $SO_2$ reduction can be achieved in stages by SI (sorbent injection) technology. Low-$NO_x$ burners should be installed as the current ones wear out.

Maritza East 2

Same as Maritza East 1, except that Unit 8 with an FGD system should be completed and the 4 older units that have a worse heat rate should be considered for decommissioning as replacement power is available. Work on these power plants should increase availability enough to enable shutdown of older units.

Maritza East 3

Same as Maritza East 1, except that slagging problems and coal crushing problems should be addressed to increase availability.

Varna

Coal supply reliability should be increased to increase the availability of the plant. Use low-$NO_x$ burners as the old burners wear out. Implement SI or equal technology or import lower sulfur coal to reduce $SO_2$.

Bobov Dol

The current mining site should be closed in phases. The power plant can be supplied with lower sulfur coal to reduce $SO_2$ emissions along with SI or equal technology. Low $NO_x$ burners can be installed as the old burners wear out.

Ruse

Assure adequate coal supply to get through the winter. Emissions could be substantially reduced by switching over to natural gas or imported lower sulfur coal.

## 19.2 Non-Power Plant Emission Sources and Issues for Consideration

The focus of this study has been primarily on existing fossil-fired power plants. These plants constitute the source of baseload electric power generation now and in the future. Interest in the control of current and future emissions remains an important goal and an essential feature of an overall control strategy. However, non-power plant sources of emissions and their control will require a commensurate level of attention now and in the future. As has been noted in this study, the combination of district heating plants, dependence on briquettes for home heating, refineries, chemical plants, and coal-fired boilers associated with other industries including cement plants are all major contributors to atmospheric pollution. Thus a strategic planning approach to this and related issues requires a certain amount of broadening of scope and outlook regarding both near term actions and long term goals and decisions.

A similar analysis should be conducted on an industry to industry basis with the attempt to incorporate the most economic plan to reduce emissions in a particulate air basin. The emphasis would be to target the highest emitting plants first and where the pollution control investment will do the most good.

A part of this follow-up study should be to evaluate whether it make sense to keep a high polluting industry or plant in business in view of competitive economic considerations. Any major industry disruptions should be done in stages to minimize job eliminations and the associated society impacts.

## 19.3 Strategic Planning Matrix for Electrical Energy and Environmental Considerations

Consideration of optimal choices regarding the generation of electricity and the protection of the environment is one of the more difficult challenges of electric utilities. To some extent the choices are simple, but the decision making process leading to these types of choices is often protracted and difficult. To some extent, the major issues are air, water, and solid waste pollution and control balanced against the current and viable energy supply alternatives such as hydroelectric, thermal (fossil-fired) and nuclear power generation sources. Table 19-2 presents a strategic planning matrix which assesses these environmental impact factors and electricity supply sources. The matrix is used to rate the overall environmental impact of each source and comparing them. The initial conclusion is a decided preference of hydro, followed by nuclear and last fossil fired plants considering strictly environmental criteria. However, other factors such as cost and dependency on out-of-country sources of energy resources will tend to weight these factors differently and alter the outcome.



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Table 19-2
Strategic Planning Matrix for Energy and Environmental Considerations

| Environmental Impact Factors | Electricity Supply Sources | | |
|---|---|---|---|
| | Hydro | Thermal | Nuclear |
| Air | 3 | 1 | 2-3 |
| Water | 3 | 2 | 3 |
| Waste | 3 | 1 | 2-3 |
| Total | 9 | 4 | 7-9 |

Scale/Legend

3 - Best
2 - Average
1 - Poor

Conclusions

1. To bring thermal power sources in line with others will require major investment.

2. Nuclear best option, but not popular.

# 20.0 CONCLUSIONS AND RECOMMENDATIONS

## 20.1 Conclusions

The plants reviewed individually and collectively represent an electric power generation system/capacity system which will currently meet anticipated demand for electricity along with current hydro and nuclear capacity components. However, the existing thermal plants will require significant changes in operation, fuels, and controls of emissions.

The plants reviewed universally demonstrate a resourcefulness among the plant management and staff to keep units in service despite issues with fuel quality, fuel availability, materials and equipment failures, and spare parts availability. This resourcefulness should be encouraged and rewarded. However, efforts need to be intensified and accelerated in the areas of plant maintenance, housekeeping, and organizational change at all levels of the plant operation to enhance plant working conditions, plant performance, and overall perceptions regarding station operation.

Emission controls to meet current and proposed standards and limits will need to be applied to ameliorate local and transboundary air pollution. However, controls and practices in this area need to be done in a phased and staged manner and on a plant specific basis. Emission reduction can be accomplished through not only stack emission control as well as fuel changes, load management, and station housekeeping changes.

NEC needs to secure an independent design basis for all plants within its system in order to enjoy the benefit of readily available design information, drawings and system descriptions as a basis for current and future plant changes related to emission control, plant betterment and/or plant rehabilitation. Manual and computer-based methods for documentation and retention of design basis information would be appropriate.

## 20.2 Recommendations

1. Retain all plants, but change the types of service expected from each.

2. Plants will require some changes to allow them to perform more efficiently and comply with current and expected environmental limits.

3. Some plants will need improvements in fuel, fuel quality, and plant operation and equipment.

4. Plants will need improvements in emission control, but implemented on varying schedules. Emission control including plant combustion emissions as well as fugitive emissions from coal, ash and selected sources.

5. Plants will need to institute a higher level of intensity regarding operation, maintenance, housekeeping and spare parts availability.

6. Currently power plant emission sources are major contributors to poor air quality in Bulgaria. However, other stationary point sources are also significant. Suggested changes for emission control for power plants will substantially reduce the relative environmental risk. Non-power plant emission sources will require attention to improve local and regional air quality and reduce environmental risk.

7. Air quality improvement is the major area of environmental betterment and suggested plant changes will accomplish this objective. However, improvements in water treatment, waste disposal and noise control present opportunities for improvement.

8. Maritza East plants will require some form of $SO_2$ and $NO_x$ emission control, and improvement in particulate control. However, improvements in delivered coal quality through the removal of soil, moisture and overburden will be necessary to improve plant performance. Maritza East 1 may require new combustion technology changes.

9. Varna will require some form of $SO_2$ and $NO_x$ emission control and improvement in particulate control. However, major changes in fuel quality such as lower sulfur imported coal should be considered.

10. Ruse plant will require some form of $SO_2$ and $NO_x$ emission control and improvement in particulate control. However, major changes in fuel quality such as low sulfur imported coal, conversion to natural gas, and/or new combustion technology changes should be considered.

11. Bobov Dol plant will require some form of $SO_2$ and $NO_x$ emission control and improvement in particulate control. However, major changes in fuel quality such as low sulfur imported coal, conversion to natural gas and/or new combustion technology should be considered.

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