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Slovakia Energy Policy Review

Final Report

Prepared for

U.S. AGENCY FOR INTERNATIONAL DEVELOPMENT

by

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BECHTEL

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Executive Summary

Introduction

In March, 1993, Dr. Robert Ichord, USAID Chief for Energy and Infrastructure, Europe Bureau, met with Slovak officials responsible for various aspects of energy policy. On the basis of these discussions an approach to providing technical assistance in the energy sector was developed. Funding for this work comes from the USAID Regional Energy Efficiency Project- Electric Power program. This assistance has included support in evaluating restructuring alternatives for the power sector (carried out in March and April of 1993) and presentation of a regulatory seminar on May 17 and 18, 1993.

A previous report contained a review of the draft Energy Concept Report prepared by the Power Research Institute (EGU) in May 1993 and a proposed workplan for assistance in energy policy development. In July and August, activities focused on the following areas: overall planning issues and methodology, including scenario analysis and generation dispatch simulation; reviews of coal and natural gas issues; and the initiation of a joint Bechtel/EGU case study to demonstrate the use of planning software. A follow-up visit was made in October and November to review case study progress.

The following experts conducted these activities:

• Energy Planner and Team Leader	Bechtel
• Economist and Institutional Analyst	Bechtel
• Power System Planner	Bechtel
• Natural Gas Expert	Consultant
• Coal Expert	Horizon Coal (subcontractor to Electrotek Concepts, Inc.)

In summary, task activities conducted included the following:

- Review of the final Energy Concept Report prepared by EGU (contained in May 1993 report)
- Economic review of options for the Units 1 and 2 of the J. Bohunice nuclear power plant (contained in May 1993 report)
- Review of macroeconomic assumptions and institutional issues associated with Slovak energy policy development (Attachment C)
- Development of independent reviews of the coal and natural gas sectors (Attachment D and E)
- Energy Workshop on August 18, 1993 (list of attendees contained in Attachment B)
- Purchase of the ELFIN model (developed and distributed by the Environmental Defense Fund) for the Ministry of Economy (description of model contained in

Attachment F)

- Translation of document describing ELFIN algorithms from English to Slovak
- Training in the use of the ELFIN model as applied to the case study in October 1993
- Final case study analysis in December 1993 (input and output for case study contained in Attachment G)
- Energy Policy Review seminar on December 8, 1993 summarizing these activities (vu-graphs associated with this presentation contained in Attachment A).

The Ministry of Economy was the lead government agency for these activities, along with their contractor, EGU. The following additional organizations were contacted as part of these activities:

- Ministry of Finance
- Slovensky Energeticky Podnik (SEP)
- Slovensky Plynarensky Priemysel (SPP)
- Nafta Gbely
- Slovnaft Refinery

The following sectors summarize the results of the work conducted for this task.

Scenario Analysis and Institutional Issues

The purpose of this task was to provide guidance with respect to the development and use of scenario analysis in the energy planning process. The task reviews the role and purpose of scenarios, the development of scenarios,reviews the Energy Concept Report scenarios and suggests possible alternatives.

The Energy Concept Report sets out three alternatives which formed the basis for all subsequent analysis of energy demand and supply. The three cases basically center on assumptions regarding the deactivation of Bohunice and the phase in of Mohovce. In addition to these key assumptions there is also an economic forecast, which was developed by the Economic Research Institute. This forecast sets out alternative growth paths. The upper case forecasts growth at 3.1% per year from 1995 to 2010, while the lower shows a growth rate of 1.4% over the same period. Both cases indicate the bottom of the economic cycle will be reached in 1994.

A review of these alternatives indicated that there was no explicit linkage between the economic forecast and the energy demand forecast. Furthermore only one forecast of total primary energy supply is presented so it not possible to tell which case it represents. Other parameters that one would expect to be set out are also missing such as crude oil prices,linkage of fuel price forecasts to costs, and assumptions regarding income levels. All of these are important in developing relationships between economic activity and energy demand. In summary the scenarios contain a number of deficiencies which limit

their value significantly. More importantly,they are deficient because they do not present alternative visions of the future, rather they appear to be variations on a single vision.

Five alternative scenarios were outlined which vary from an optimistic view of the future to a highly pessimistic scenario. The range of cases illustrates how the key forces affecting the energy sector can be classified and the interrelationships among them examined. It should provide a useful guideline for future energy planning exercises.

Based on the review of the energy planning process it appears fragmented. Accordingly, if energy planning is considered a necessary and continuing activity in the design and development of economic an energy policy, then strengthening of these capabilities will be necessary.

The following recommendations emerge from the scenario review:

- The use of scenario analysis should continue to be refined and expanded. In particular the scenarios need to be better developed and more clearly described. There should also be an explicit specification of the key parameters such as GDP, energy costs, income levels and prices to better understand how these factors interrelate in their impact on the economy, energy mix, and energy policy.
- The implications of the scenario analysis should be clearly stated in the beginning of the Energy Concept Report with respect to scope and emphasis of energy policy
- Greater use should be made of simulation and other planning models
- A uniform approach to energy data collection should be developed including the systematic development of energy balances

Coal Sector Review

Coal consumption was approximately 15 million tonnes in 1993. Of this, approximately 75% is consumed by the power, industrial, and residential/commercial sectors in relatively equal amounts. The remaining consumption is for coking coal and for fuel district heating plants.

Coal supply is from imports from the CIS, from the Czech Republic, with approximately 3.5 million tonnes per year supplied from domestic sources. Domestic coal is supplied by five mines. The Zahorie and Handlova mines were visited as part of this review.

The major conclusions that were drawn from the review of the coal sector were the following:

- The economics of domestic coal production are marginal. While some productivity gains are possible from improved mining techniques, the comparatively low productivity statistics of the coal sector reflect extremely difficult geologic conditions

requiring high labor intensity.

- The contribution of labor cost to overall coal costs is comparable to the U.S. (25%-30%). However, current low wage rates in Slovakia and increases in response to improved economic conditions will have a significant affect on future costs.

- Geologic conditions require a relatively steady rate of production, precluding using domestic coal as a swing fuel.

- Current annual production levels of 3.5 million tonnes could be increased to 4.2 million tonnes without significant capital investment.

- Markets for domestic brown coal production will likely decline as the users comply with new air emission standards unless investments are made in coal cleaning or post-combustion cleanup technologies.

Given the fact that coal is the only domestic energy resource aside from hydro and the social impacts of employment in the mining sector, the maintenance of current production levels appears reasonable. However, future work should attempt to quantify the cost of this policy.

Natural Gas Sector Review

Natural gas use in Slovakia currently ranges from 5.5 to 5.7 billion cubic meters per year. Slovakia imports about 96% of its current natural gas requirements from the Commonwealth of Independent States (CIS), the remaining being local production. The imported gas enters Slovakia at the Ukraine border. Approximately 73 percent of the Slovak gas requirement is transported by the Brotherhood Pipeline (IGP-1) traversing the country from east to west terminating at the Czech border. The remaining amount is supplied by the transit gas pipeline, the West European supply system, which roughly parallels IGP-1.

IGP-1 is operated by SPP. Connecting laterals and distribution lines serving outlying population centers, as well as the supply/withdrawal lateral serving the underground gas storage at Lab, are also operated by SPP. The underground reservoirs are owned and operated by Nafta Gbely, a private company. These facilities were visited as part of the natural gas sector review.

SPP receives gas on a substantially level rate during the year from its CIS suppliers; therefore, due to high seasonal variability in the use of gas, the underground gas storage is essential to the efficient operation of IGP-1 and to the maintenance of gas supply during peak demand periods.

The following are comments on areas that we believe should receive additional emphasis

in the natural gas sector in future versions of the Energy Concept Report.

- Future work should address the potential for diversification of natural gas supplies and the costs associated with increasing security of supply.

- Future energy policy work should address price regulation for natural gas. Currently, the Ministry of Finance has this responsibility. Should this policy be continued or should a new body be established?

- The methods used in calculating various requirements should be fully explained as part of future Energy Concept Reports (e.g., the method of computing natural gas underground storage requirements as a function of gas demand).

Technology Transfer in Power Sector Analysis

One of our recommendations in our earlier review of the economic analysis of alternative strategies for Bohunice V-1 was the need to use power system dispatch simulation in evaluating power system options. Based on this recommendation the following activities were carried out with EGU.

- Demonstration of the ELFIN power system dispatch simulation model and initial training.
- Demonstration of economic analysis worksheet for use in evaluating alternative heat and power strategies (using ELFIN output)
- Demonstration of worksheet for calculating natural gas storage requirements (using ELFIN output)
- Purchase of the model for the Ministry of Economy for use by EGU
- Translation of technical description of ELFIN model from English to Slovak
- Assistance in applying the ELFIN model and economic analysis worksheet to a case study
- Modification of existing ELFIN data set of the Slovak power system for the case study.

The case study is discussed in the following section.

Case Study

A case study was conducted with EGU. The primary objective of the case study was to demonstrate the use of least-cost planning techniques, particularly the ELFIN model, to support decisions in the power sector. The secondary objective was to address some key questions of interest to Ministry of Economy decision makers. Based on discussions with

the Ministry, the case study addressed three following questions:

- Should Vojany I be rehabilitated before natural gas GCC capacity installed for combined heat and power application?
- Should natural gas use in condensing cycle be replaced by natural gas GCC? When?
- What is the potential role of imports?

A number of planning studies, aside from the Energy Concept Report, have addressed these questions in varying degrees of detail. These include the Tractebel Study, ongoing SEP planning studies, and the G-7 report. To a large extent these studies have not addressed the role of combined heat and power and it is felt by the Ministry that consideration of heat benefits of combined heat and power applications could affect development decisions.

Key assumptions used in the case study are:

- Load forecast as illustrated in Figure 1. As can be seen this forecast is lower than that of the Energy Concept Report, but higher in the long term than that used as a reference in the G-7 report

- Gradual reconstruction of Bohunice V-1- was assumed with decommissioning in 2000 and 2001.

- Completion of Mohovce I was assumed to be in 1996 and 1997, with 50% of the output exported.

- Completion of Mohovce II was assumed to be in 2000 and 2001, with 50% of the output exported.

- The value of heat was placed at the cost of producing heat for district heating on a stand-alone basis from a natural gas boiler.

Detailed assumptions are contained in Attachment G. The results of the case study indicate the following:

- There is an indication that combined heat and power GCC development is more cost-effective than rehabilitation of Vojany I unless rehabilitation efforts are can substantially reduced fixed operating costs at the plant.

- While there is an indication that new GCC capacity will be more cost-effective than continued operation of Vojany II Units 5-6 on gas when capacity factors reach

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greater than approximately 20% (projected for the year 2000) at projected gas price levels, the economic advantage is limited by operating constraints associated with combined heat and power operation.

- Potential imports based on long-term contracts may well be a cost-effective alternative to the construction of capacity based on fossil fuels. There is substantially more value to contracts which can be used on an as-needed basis as opposed to baseloaded.

The results of the case study should not be considered as conclusive. The economics of the options considered are highly dependent upon load growth and could be affected by the future of the Bohunice V-1 and Mohovce plants. Future energy policy development in Slovakia should include a careful review of capital cost data, both for Vojany I rehabilitation, but also for GCC combined heat and power applications. This will require greater attention to the characterization of thermal heat loads in various communities. Future consideration of import contracts should include the identification of import opportunities and refinement of potential contract terms.

Final Seminar

A seminar presenting energy subsector reviews and case study results was presented on December 8. An open discussion followed and the major issues brought forward by participants were as follows.

Mr. Novák of the Nuclear Regulatory Administration (NRA) indicated a concern on the impact of future gas prices on future demand for gas. With respect to future plans for Bohunice V-1, he indicated that any plans for the plant, such as gradual reconstruction, would have to be shown to be superior to fundamental reconstruction from a safety point of view for NRA approval.

Mr. Ursíny reviewed the planning process at SEP. His presentation emphasized the complexity of the process, particularly with respect to the interaction of financial constraints. He pointed out that the case study results should only be considered preliminary since a great deal sensitivity analysis would be required to verify results. He also indicated that SEP's position was that finishing Mohovce was the most economic option open to Slovakia and that the focus of the case study on other issues should not obscure the importance of that option.

Mr. Mošat of MSE pointed out the importance of applying least-cost planning and demand-side management principles to the power sector.

Mr. Julis of the Antimonopoly Office posed some questions concerning macroeconomic assumptions in the case study and pointed out the importance of such studies to the emerging regulatory process.

Mr. Sestrienka reviewed the major findings of the Energy Policy Review and pointed out the need for continued work in a number of areas including:

- more detailed analysis of combined heat and power applications to reflect the unique characteristics of various communities (i.e, large heat loads, nearness to domestic gas fields, etc.) in order to better prioritize investments
- additional consideration of options for Vojany and Novaky
- study of conservation applications
- geothermal development

He emphasized the need to analyze energy options from an integrated point of view in order to reflect the overall energy efficiency benefits of combined heat and power applications and the importance of the analytical techniques introduced in the case study to implementing this integrated approach in future planning.

Attachment A

Energy Policy Review Seminar

December 8, 1993

presented by
Bechtel Corporation

and funded by
U.S. Agency for International Development

Agenda

Discussion of Scenario Analysis and Sectorial Presentations	Wayne Mikutowicz Floyd Davis
Case Study Presentation	
Overview	Floyd Davis
Methodology	Miljenko Bradaric Argia Popovicova
Results	Alena Salamanova
Observations	Floyd Davis
Conclusions and Recommendations	Floyd Davis
Open Discussion	

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Energy Policy Review

Objectives

- Provide a review of the Energy Concept Paper developed by EGU for the Ministry of Economy
- Provide technical and economic analysis for key issues in specific energy subsectors
- Provide software to support local development of future energy policy evaluations

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Energy Policy Review Activities

- Review of Economic Analysis of Bohunice V-I Options, May 1993
- Review of Draft Energy Concept Report, May 1993
- Power System Dispatch Simulation Software - Technology Transfer
- Conduct Case Study

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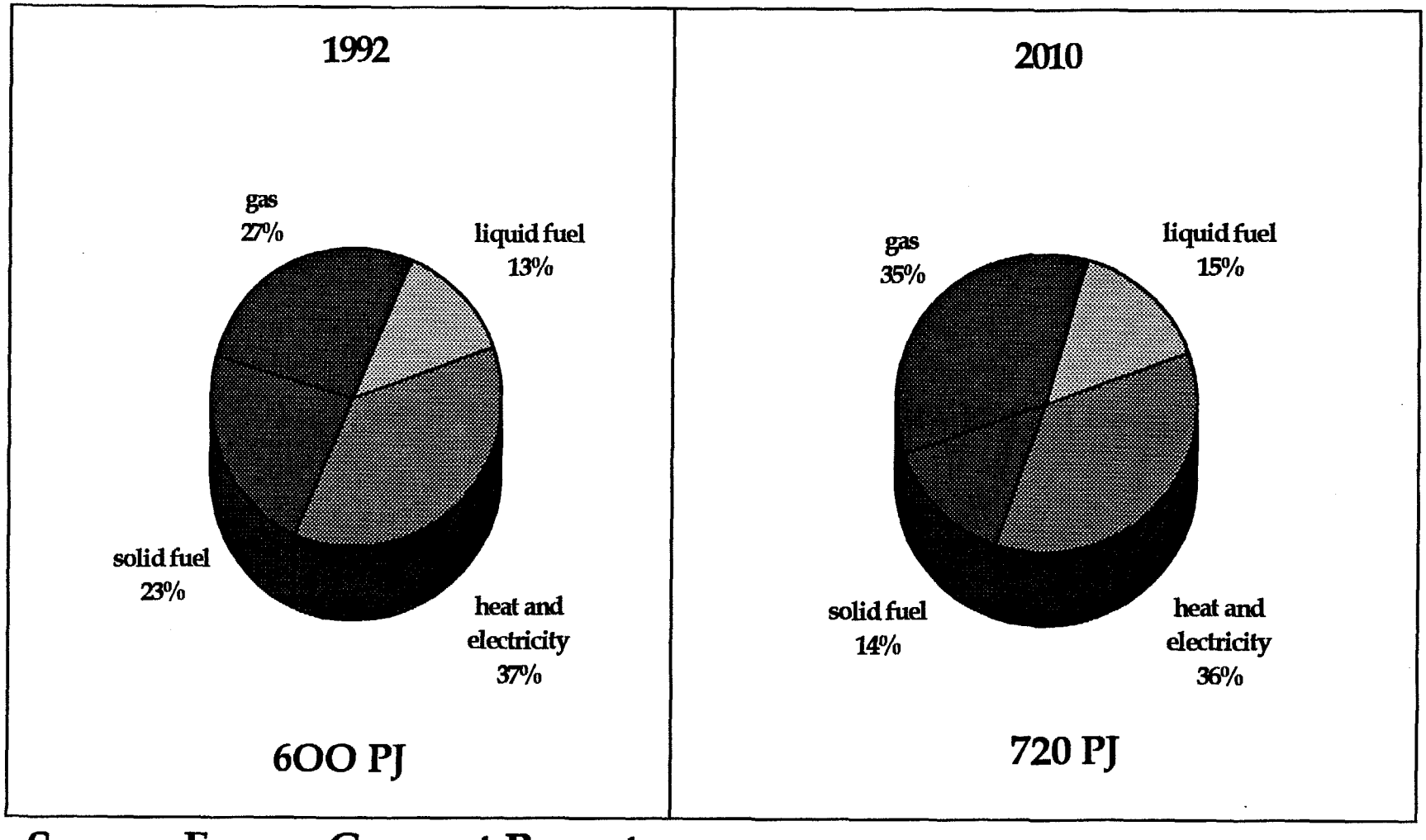
Overall Energy Demand



Source: Energy Concept Report

Overall Energy Planning

- Development of planning scenarios (factors not under control of decision- maker, such as economic growth)
- Development of alternative development strategies (actions that can be controlled by decision-maker such as power plant reconstruction)
- Analysis of strategies under different planning scenarios
- Recommendations

Energy Strategy Development

- Develop sectorial strategies (e.g., gas sector, coal sector, power sector, etc.)
  - technology screening
  - overall strategic concerns (e.g., restructuring, fuel diversification)
  - use of optimization techniques
- Consider interaction between sectors (e.g., gas storage requirements with increased use of gas in power sector).
- Adjust sectorial strategies accordingly.

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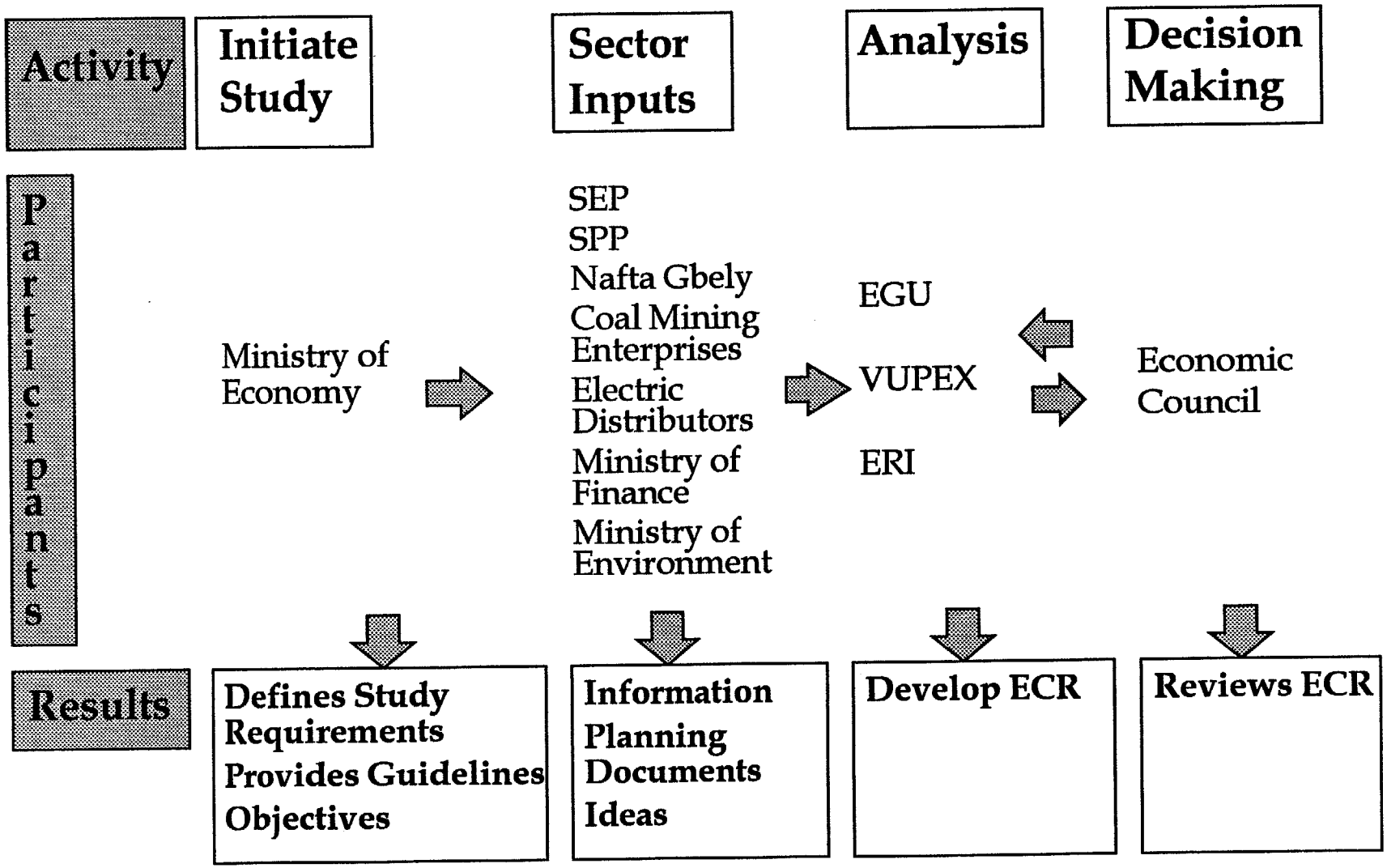
Institutional Energy Planning Framework



Scenario Analysis

Objectives:

- Define Role & Purpose
- Approach
- Review ECR Scenarios
- Suggest Other Possible Scenarios

The Role and Purpose of Scenarios

- Scenarios Describe Future Outcomes Under Alternative Situations

- Two Purposes
  1) Protective - clarify risks
  2) Strategic - identify options

- Provide Insight to Key Decisionmakers

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An Approach to Scenario Development

Step 1 – Develop a Vision of the Future

Step 2 – Analysis of Economic and Energy Factors

- External Factors
- Internal Factors

Step 3 – Relate Results of Analysis to Key Forecast Parameters

- GDP Forecast
- Income Forecast
- Price Forecast
- Aggregate Energy Demand

Step 4 – Use This Information To Develop Alternative Scenarios

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Recommendations

- Scenario Analysis Should Continue to Be Refined and Expanded
- Scenario Implications Should Be Clearly Explained in the ECR
- Expand the Use of Planning and Simulation Models
- Uniform Approach to Energy Data Collection and Presentation
- Energy Planning Capabilities Should be Strengthened

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Natural Gas Sector Review

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Natural Gas

Objectives

- Review Gas Situation
- Assess Need for Gas Storage
- Implications for Government Policy

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Gas Demand

- Role of Gas Could Change Significantly

	1992	2000	2010
Volume	5.6 $Mldm^3$	8.8 $Mldm^3$	10.5 $Mldm^3$
% of TPES	25%	28%	35%

- Driving Force Would Be Requirements for Electric Power

	1992	2000	2010
Residential/ Commercial	18%	17%	19%
Industrial	79 %	59 %	59 %
Electric	3 %	24 %	22 %
	100 %	100 %	100 %

- Electric Load Will Affect Demand for Gas

Gas Supply

- **Implications for Gas Supplies**

	1992	2010
Domestic Prod.	3.5%	4.8%
CIS Gas	96.5%	81-95%
Other Sources	0%	0-14.2%
	100%	100%

- **Future Cost of Gas (1992 Sk)**

	1992	2010
Avg. Cost of Gas	2.15 Sk/m^3	2.70-3.00 Sk/m^3
Avg. Cost to Industry	3.21 Sk/m^3	3.76-4.06 Sk/m^3

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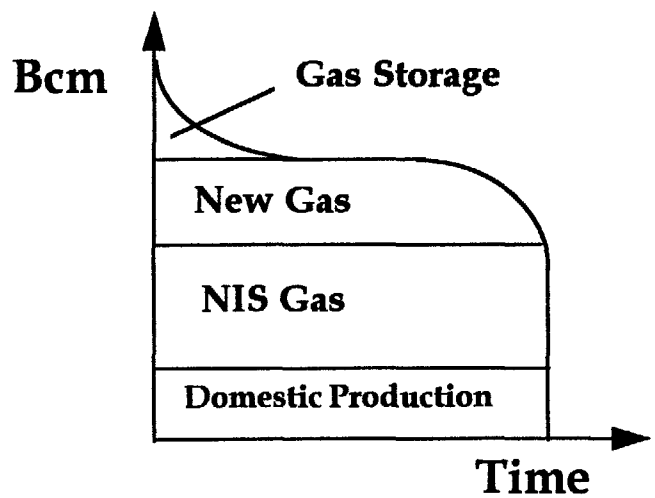
Gas Storage Developments

- Given the Dynamic Changes for Gas Supply and Demand - Gas Storage Will Play an Increasing Role in Meeting Peak Demands and Security of Supply Considerations
- Currently Peak Demand is 130 % of average Daily Demand or 35 Million m^3
- Current Gas Storage Peak Day Sendout of 24 Mm^3 is adequate to meet peak day requirement
- Planned Storage Capacity should add another 21 Million m^3 over the next ten years which should be meet projected peak demands

Implications for Energy Policy

- Gas Pricing: Market Based Prices Will Help to Achieve National Objectives
  - Appropriate action required for Tariff Design Analysis
  - Better measurement and cost estimation
  - Role of price regulation needs to be evaluated
- Gas Supply Planning: Least Cost Planning Techniques Should be Applied to the Gas Sector



Implications for Energy Policy (continued)

- Demand Side Management Must Also be Considered
  - Significant potential for efficiency improvements
  - Implemented through pricing and customer programs
  - Will result in better load profile and supply management
- Competitive Performance Will Impact Both Pricing and Supply Planning
  - What is the appropriate structure for SPP
  - What elements will remain a natural monopoly
  - The role of a independent regulatory body must be considered

Petroleum Sector

- Liquid Fuels are Projected to Maintain their Share of TPES

	1992	2000	2010
ECR	18% (200 PJ)	18% (200 PJ)	20% (205 PJ)

- However, The Mix of Products Will Change Significantly

1992	Product	2005
19%	Gasoline	40%
32%	Diesel Fuel	35%
2%	Jet Fuel	3%
0%	LSFO(sulphur below 1% wt)	12%
4%	Fuel Oil(sulphur below 2%wt)	-
43%	HSFO	3%
-	Home Heating Oil	7%
100%		100%

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Petroleum Sector (continued)

- Key Issues
  - Role of Slovnaft with Respect to Regional Refining Situation
  - Necessity for Crude Oil Supply Diversification
  - Interfuel Competition
  - Prospects for Imports and Exports

Coal Sector Review

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Coal Sector Overview

- Total coal consumption amounted to 15.3 Million Tonnes in 1992
  - Electric Power 25 %
  - Industry & Coking 42 %
  - District Heating 9 %
  - Residential/Commercial 21 %
- Domestic production amounted to 3.5 Million Tonnes , or 20 % of total consumption
- The majority of the production 80 % come from the Horna Nitro District
- This District also accounts for 80 % of coal mine employees

Coal Industry Structure

- The Coal Industry has been restructured on a geographic basis
- This has resulted in the formation of three mining districts:
  - Horna Nitro Distict - Hondlova, Cigel & Novaky mines
  - Modro Kamenske Loziska District - Dolina mine
  - Zahorie District - Zahorie Mine
- Mining operations in each district are state owned
- Early next year the second phase of the industry's restructuring will occur when the Zahorie and Modro Kamenske Loziska District Enterprises become joint stock companies , while the Horna Nitro District will remain a State owned Enterprise

Importance of Domestic Resources

Estimation of the economic costs of relying on domestic coal will require consideration of several factors

- Measurement of the "true" economic cost & benefit should be based on the estimation of shadow prices for labor and output
- Security of supply should take into account the risk of an interruption and the associated economic cost of such an interruption
- The environmental costs associated with coal mining should also be estimated
- The end result should provide a better basis to determine the contribution of domestic coal mining to the Nation's economic well being

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Key Policy Issues Concerning Coal

- Pure Economics of Domestic Coal Production are Marginal
- Increased Production is Limited Without Significant Capital Investment
- Conditions Require High Labor Intensity
- Labor is Approximately 25% of Cost - Wage Increase Will Have Significant Effect on Cost in the Future
- Mining Conditions Require a Relatively Steady Rate of Production
- Only Domestic Supply Besides Hydro
- Employment Levels in Mining is Critical Social Issue
- Maintenance of Current Production Levels Appears reasonable, but Economic Costs Should Be Better Quantified.

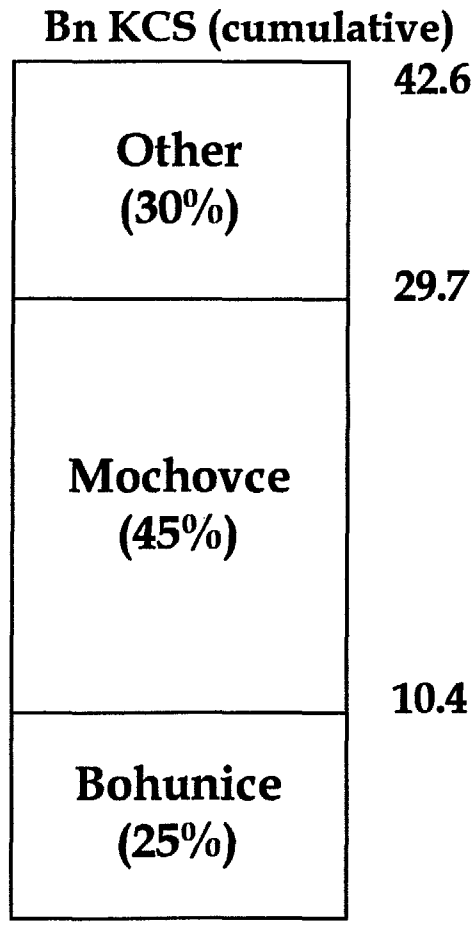
Power Sector Review

Capacity Breakdown

	Instaled Capacity	Fuel
In operation		
Bohunice V-1	2x440	Nuclear
Bohunice V-2	2x440	Nuclear
Novaky	550	Indigenous Lignite
Vojany I	6x110	Imported Coal
Vojany II	6x110	Oil and Gas
Hydro	1923	
Com. Heat and Power	330	Oil and Gas
Industrial	825	Oil and Gas
Total	6708	
Under construction		
Mochovce 1-4	4x440	Nuclear

Power Sector Overview

70% of the fixed assets are in nuclear generation



Nuclear power plant is difficult to privatize.

Studies Addressing Power System Development

- Tractebel Study
- Energy Concept Paper (EGU)
- Ongoing Planning Studies (SEP)
- G-7 Study

Critical Issues

- Load Growth
- Plans for Bohunice V-1
- Plans for Mochovce
- Rehabilitation of Plants
- Environment
- Use of Natural Gas

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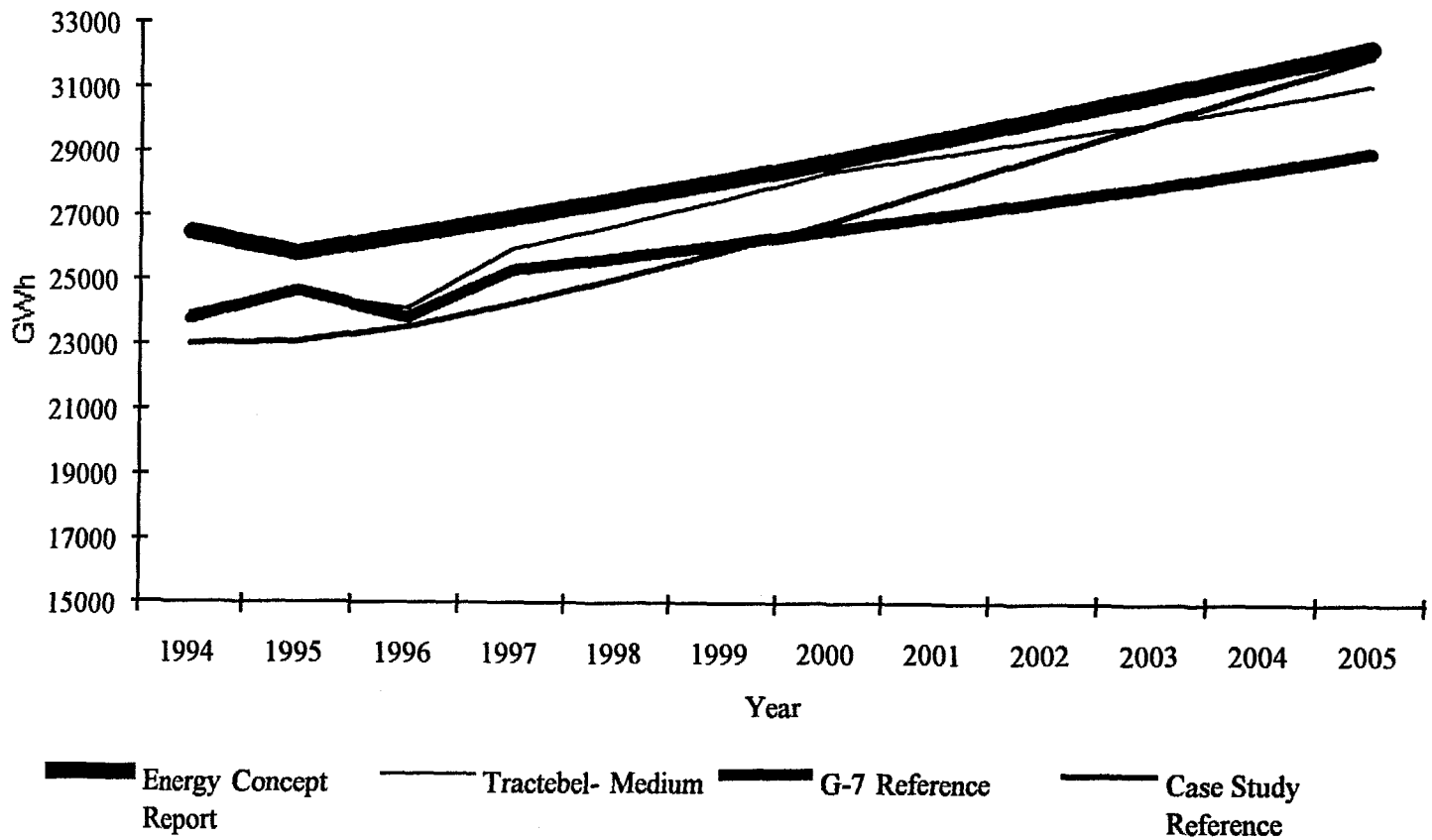
Load Forecasts

Generation Requirements



Bohunice V-1 Options

- Decommissioning by 1995
- Large Reconstruction
- Gradual Reconstruction

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Mochovce Options

- Abandon
- Complete Units 1 and 2
  - substantial foreign investment
  - sales of electricity required
- Complete Units 1-4

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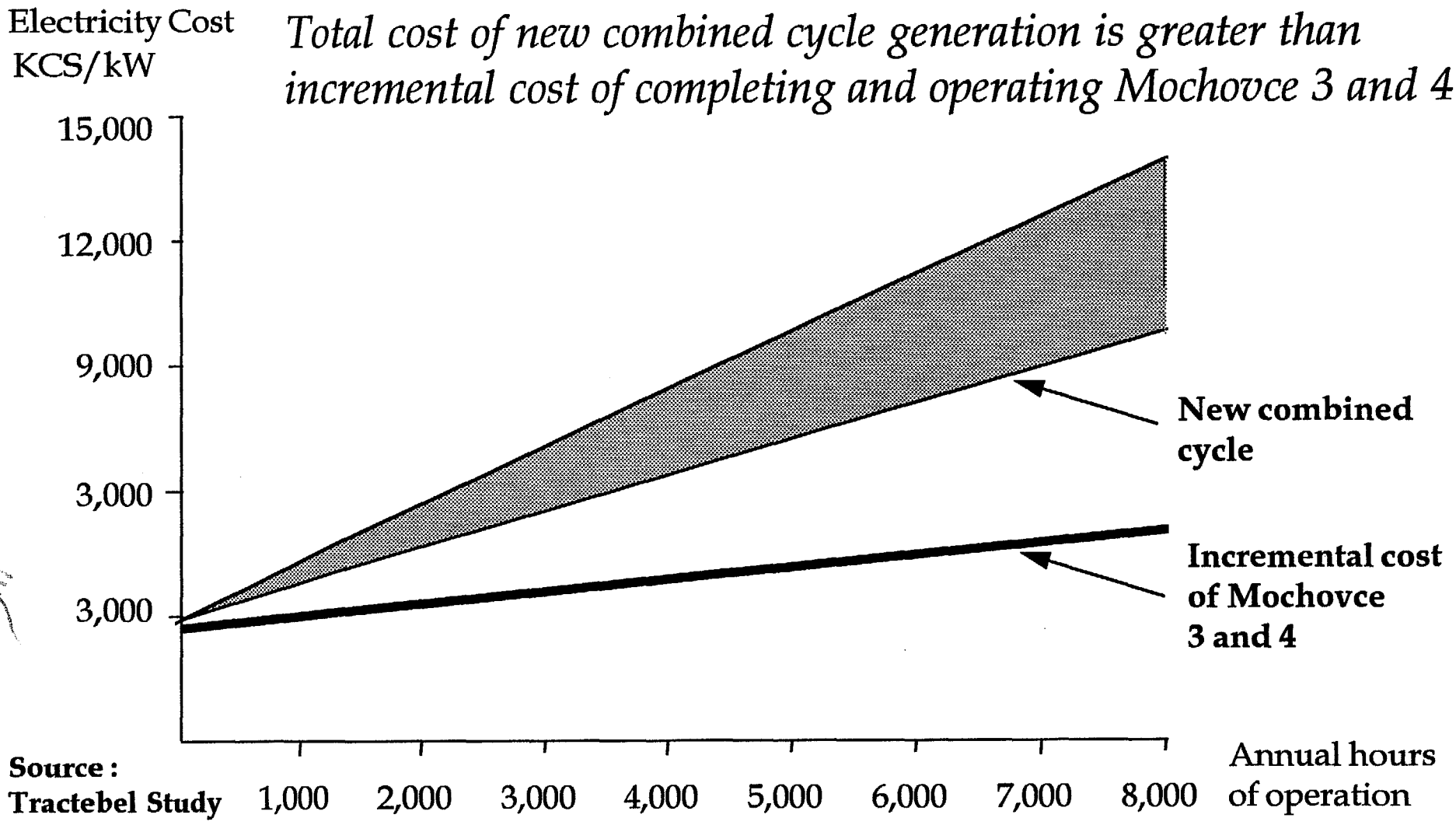
Competition for New Generation

Total cost of new combined cycle generation is greater than incremental cost of completing and operating Mochovce 3 and 4



Source : Tractebel Study

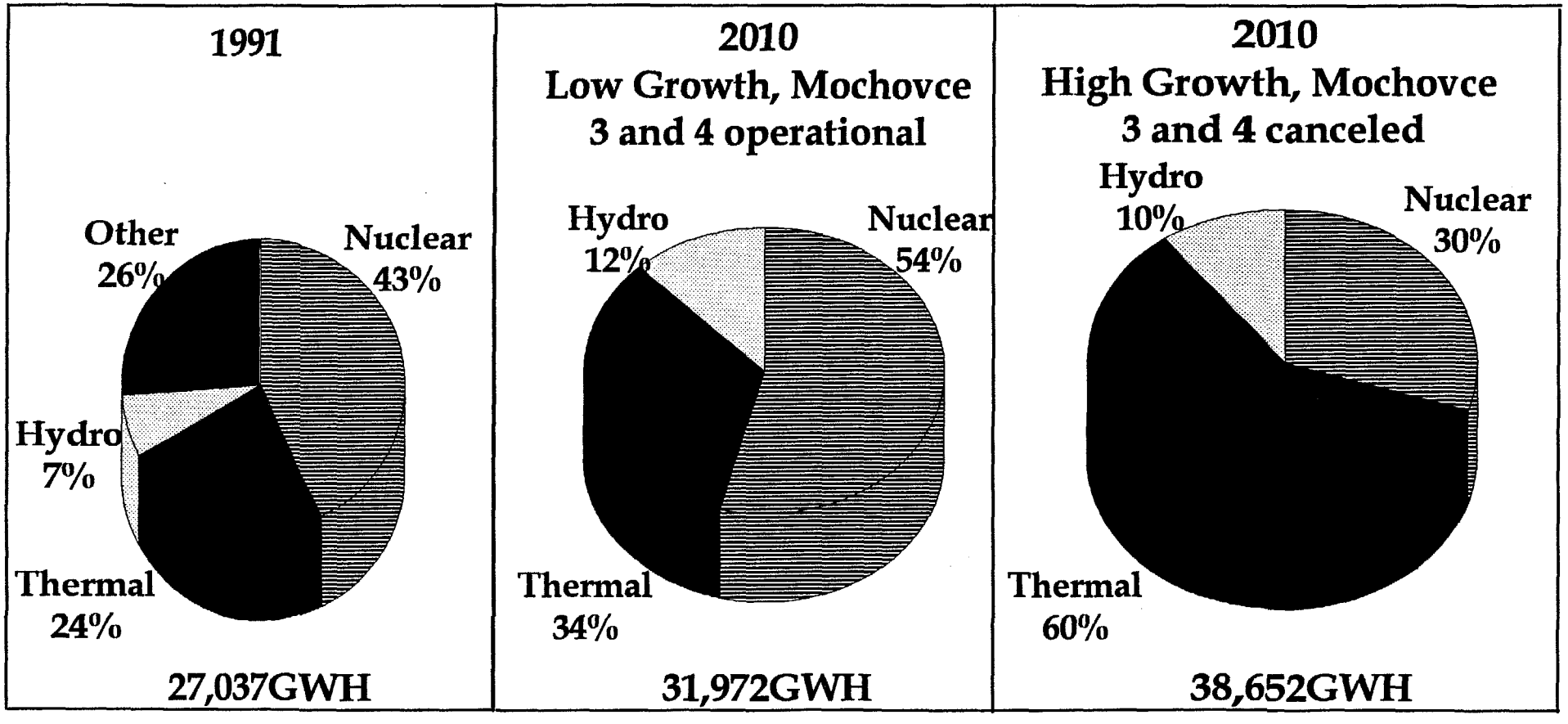
Past investment should not affect economic decisions.

Rehabilitation Options

- Novaky
  - required if indigenous thermal resources use is to be maintained
- Vojany I
  - addressed in Case Study

Use of Natural Gas

Scenarios of Generation Mix



Source:
Tractebel Study

Power System Expansion Analysis

Case Study

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Objective of Case Study

- Primary
  - to demonstrate the use of least-cost planning techniques to support decisions
- Secondary
  - to address some key question of interest to decision makers

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Questions Addressed by Case Study

- Should Vojany be rehabilitated before natural gas GCC capacity installed for combined heat and power applications?
- Should natural gas use in condensing cycle be replaced by natural gas GCC? When?
- What is the potential role of imports?

Expansion Variants

Variant 1 :

- Reference Case - draft SEP expansion plan
- Rehabilitation of Vojany units

Variant 2 :

- Retiring Vojany I units 3-6
- Additional Gas Combined Cycle units to meet load

Variant 3 :

- Most economic of Variant 1 & 2
- Retire Vojany II units 5-6
- Additional Gas Combined Cycle units to meet load

Variant 4 :

- Import energy rather then to build one Gas Combined Cycle

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Key Assumptions

Load forecast - lower than Energy Concept Report

Nuclear Power Plants

Bohunice V-1 :

- Gradual reconstruction
- Decommissioning- 1st unit in 2000, 2nd unit in 2001

Bohunice V-2 :

- Continued operation

Mochovce 1 :

- On line - 1st unit in 1996, 2nd unit in 1997
- Production of one unit is for exports

Mochovce 2 :

- On line - 1st unit in 2000, 2nd unit in 2001

Summary of Case Study Results

- There is a strong indication that combined heat and power GCC development appears to be more cost-effective than rehabilitation of Vojany I
- New GCC capacity will be more cost-effective than continued operation of Vojany II Units 5-6 on gas when capacity factors reach greater than approximately 25% (projected for the year 2000) at projected gas price levels
- Potential imports based on long-term are likely to be a cost-effective alternative to the construction of capacity based on fossil fuels

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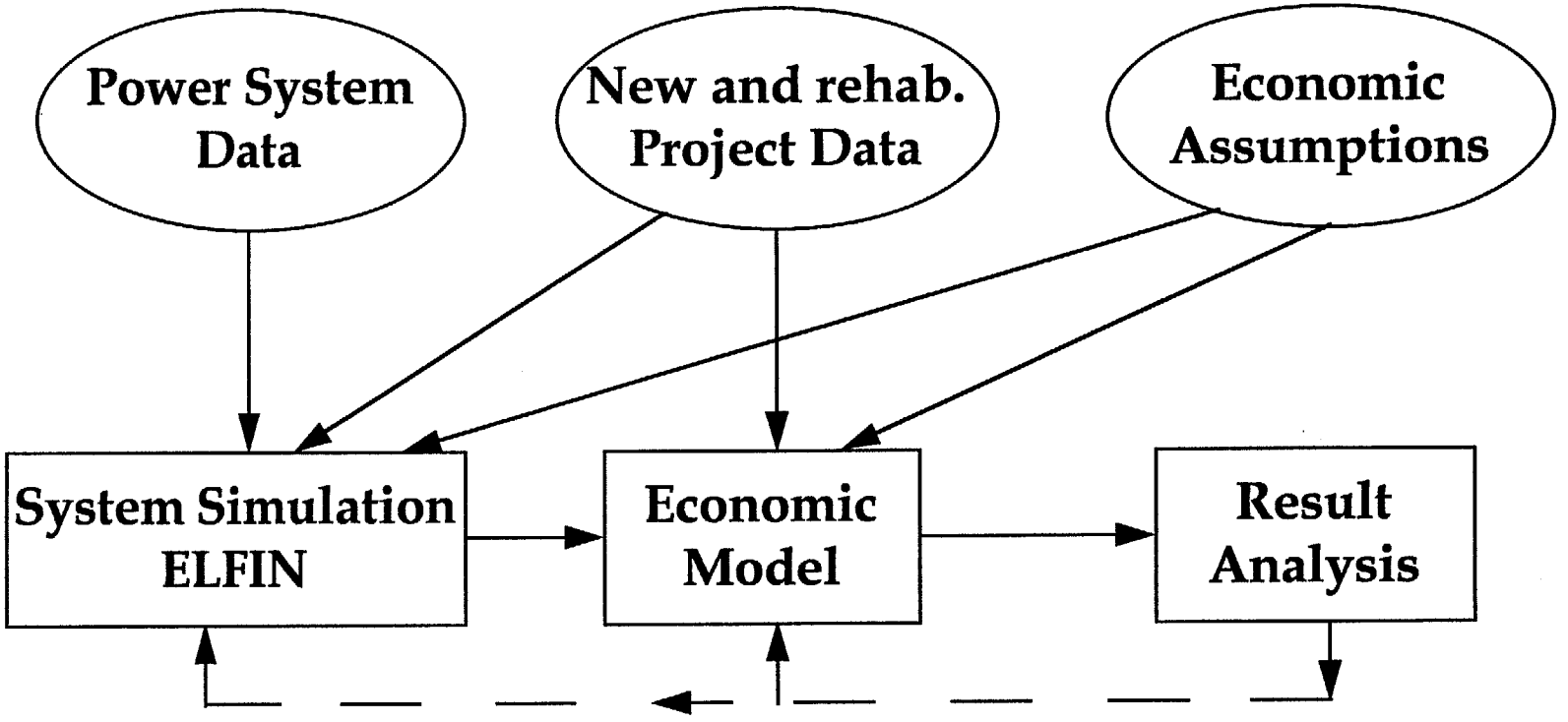
Observations on Case Study Results

- The economics of Vojany I is highly dependent upon load growth and the control of non-fuel operating costs.
- Long term import opportunities should be identified and evaluated in greater detail.
  - against other supply options
  - hedge against uncertainty

Observations (continued)

- Power system has many operational constraints.
- Outcome of operation and control studies could have important impact on development decisions.
- Operational agreements between owners of generation capacity required to ensure optimal operation (SEP and distributors)
- Options which reduce operational constraints may have significant benefits (e.g. combustion turbines)

Analytical Approach



Key Characteristics of ELFIN Generation Model

- Simulates the operation of electric utility systems

  Features :

- Load scaling
- Based on load duration curves (up to 6 x 52 per year)
  - typically monthly simulations are made
  - typically peak, intermediate, and off-peak time periods represented
- Maintenance scheduling, unit commitment, economic dispatch, multi-area calculations
- Fuel use, emissions, energy produced
- Total and marginal costs

ELFIN Model (Continued)

- Flexible input and user-controlled reporting
- Easy communication with economic, financial, and technical models
- Specialized DSM, hydro and renewables treatment
- Reliability calculation

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Utility Profile Data

- Load Forecasts and Load Shapes
- Existing Utility System
- New Plant Additions
- Economic Assumptions
- Financial Assumptions
- Cost Data

Load Model

- Yearly load represented by one or more load duration curves
- Input in the form of hourly loads - 1992 data
- Annual peak loads and energy projections supplied separately - latest SEP projections
- Load curve is scaled to fit specified peak and energy

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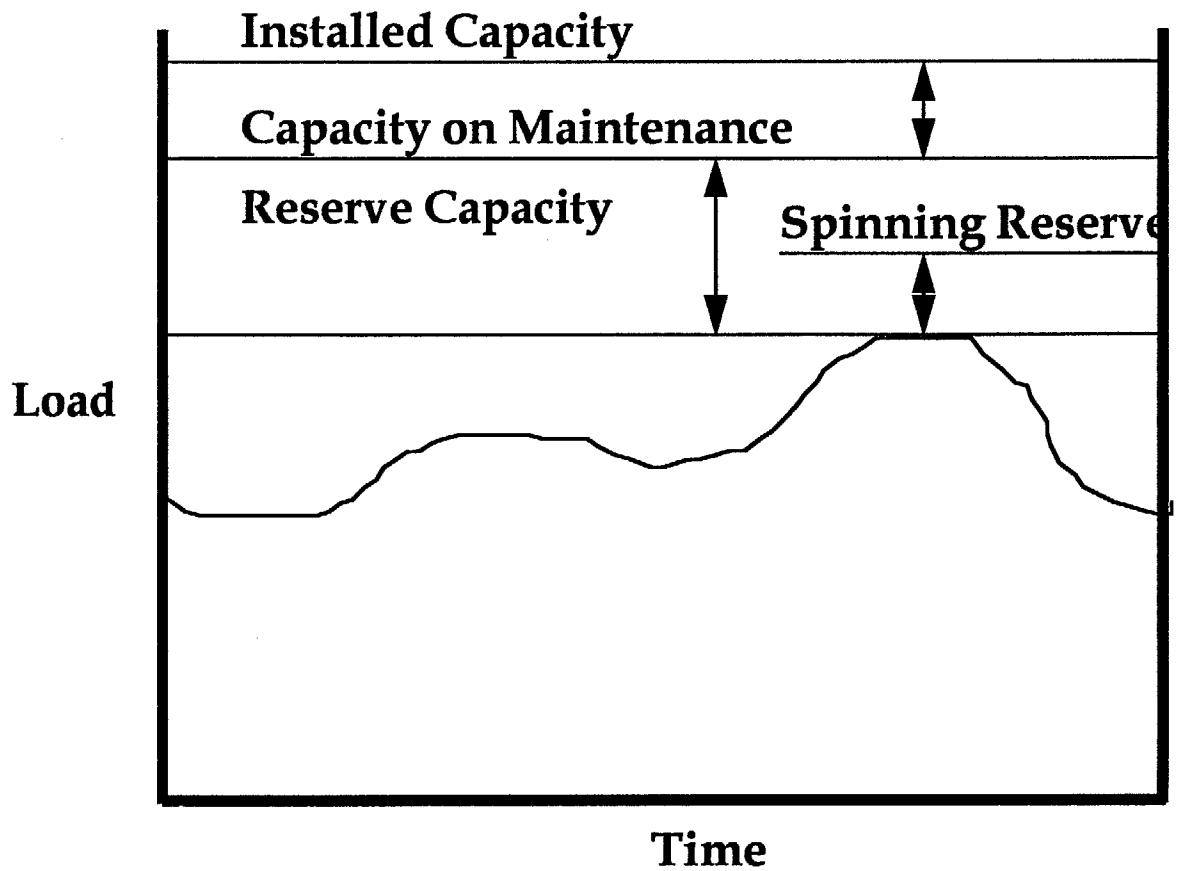
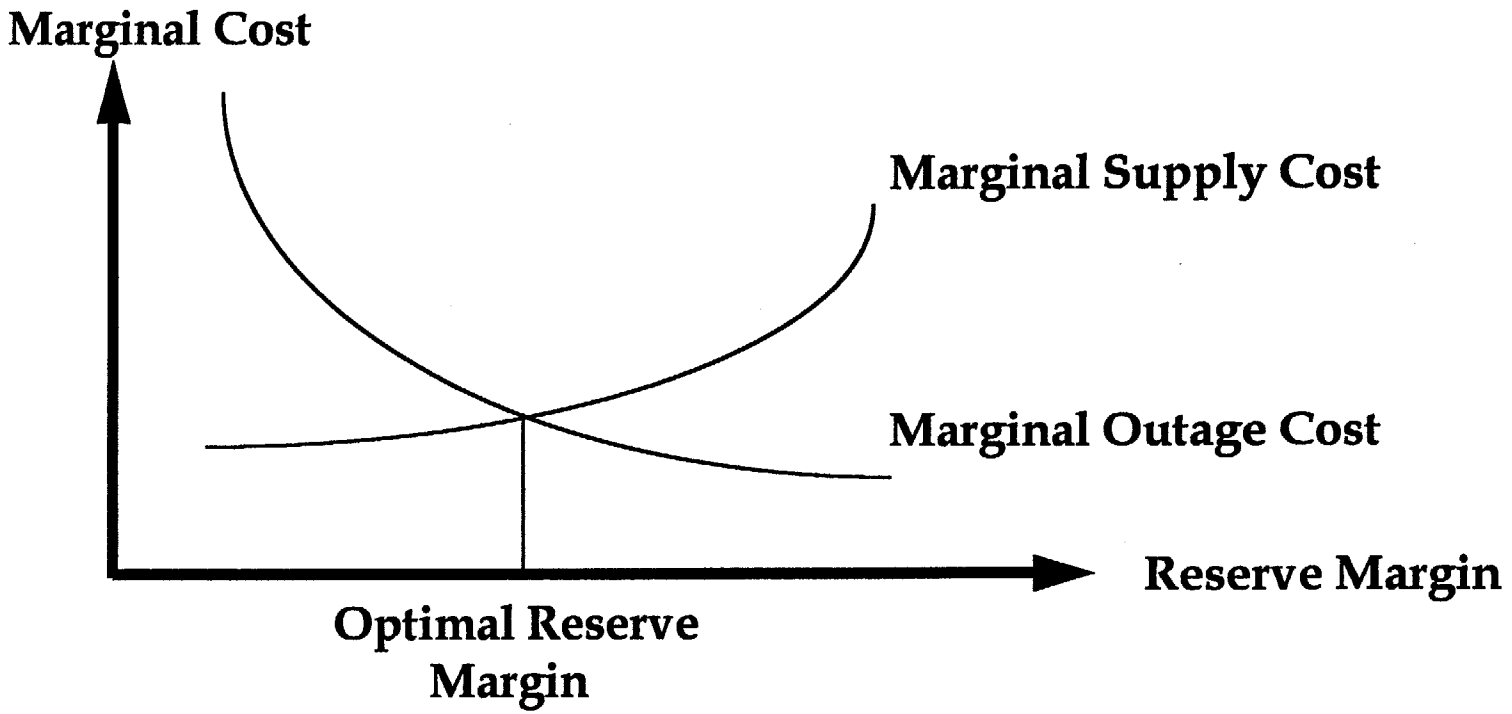
System Reserve



Optimal Reliability Level

The optimal reserve margin is at the point where marginal outage cost equals marginal supply cost



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System Reliability Measures

Deterministic

- Reserve margin
- Largest unit

Probabilistic

- Loss of load probability (LOLP)
- Expected unserved energy
- Loss of energy probability

Loss Of Load Probability Definition

- The probability that the power system will be unable to meet demand without the initiation of emergency measures
- Expressed as a percent or in terms of days per year
- Typical value in the U.S. is 1 day in 10 years
- Same value used for the Slovak power system

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Cost Data

Fixed Costs :

- Capital Costs
- Fixed Operating and Maintenance Costs

Variable Costs :

- Fuel Costs
- Variable Operating and Maintenance Costs
- Purchased Energy Costs
- Unserved Energy Costs

Economic Analysis

Spreadsheet-based custom-built economic model

Objective function :

- To minimize total present worth of investment and operating costs

Model characteristics :

- Incorporates power system dispatch information from simulation models such as ELFIN
- Calculates benefits and costs of combined power and heat production
- Accounts for end effects

Additional Factors

Additional Factors affecting planning not evaluated under the case study:

- Externalities (pollution damages, land use, health effects)
- Demand Side Management (DSM)
- Uncertainty

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Externalities

The challenge of incorporating externalities into utility decisions

- Utilities plan and operate using direct costs
- Externalities differ across resources
- Ignoring externalities distorts resource selection and use
- To consider externalities they must be valued implicitly or explicitly

Externalities (continued)

Externalities are part of social costs

Direct Cost	+	External Cost	=	Social Costs

For example
- Capital
- O & M
- Fuel

For example
- Pollution damages
- Health effects
- Aesthetics

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Externalities (continued)

Methods of internalizing externalities

- Impose control or mitigation obligations
  - environmental regulation
  - control/mitigation cost becomes a direct cost
- Assign a value to the externality
  - utility regulation
  - value of the externality becomes a direct cost
  - real cost (e.g., tax) or cost for decision-making purposes

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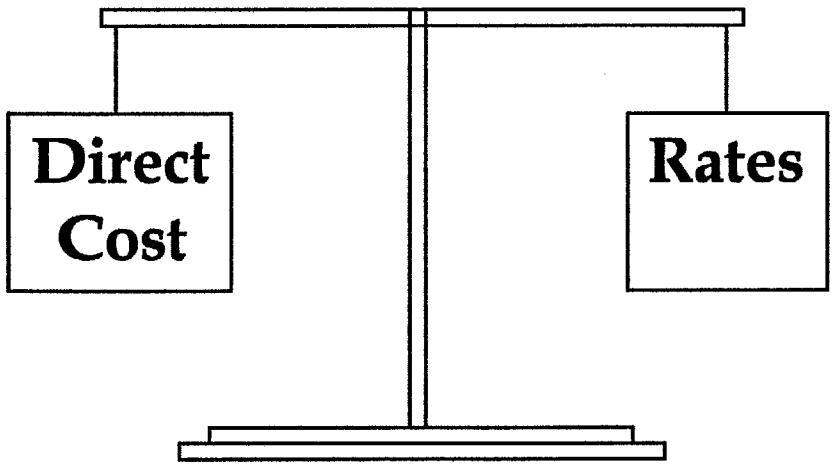
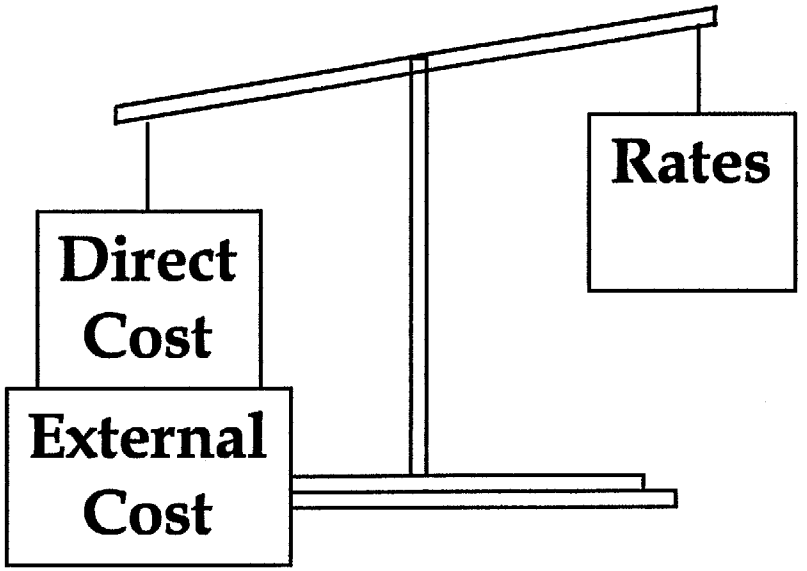
Externalities (continued)

Internalizing externalities raises rates



Without Externalities



With Externalities

Demand-Side Management

Demand-side management (DSM) is the planning and implementation of those utility activities designed to influence customer use of electricity in ways that will produce desired changes in the load shape.

Demand-side management programs :

- load management
- new uses
- strategic conservation

Uncertainty

Selected uncertainties in the planning process

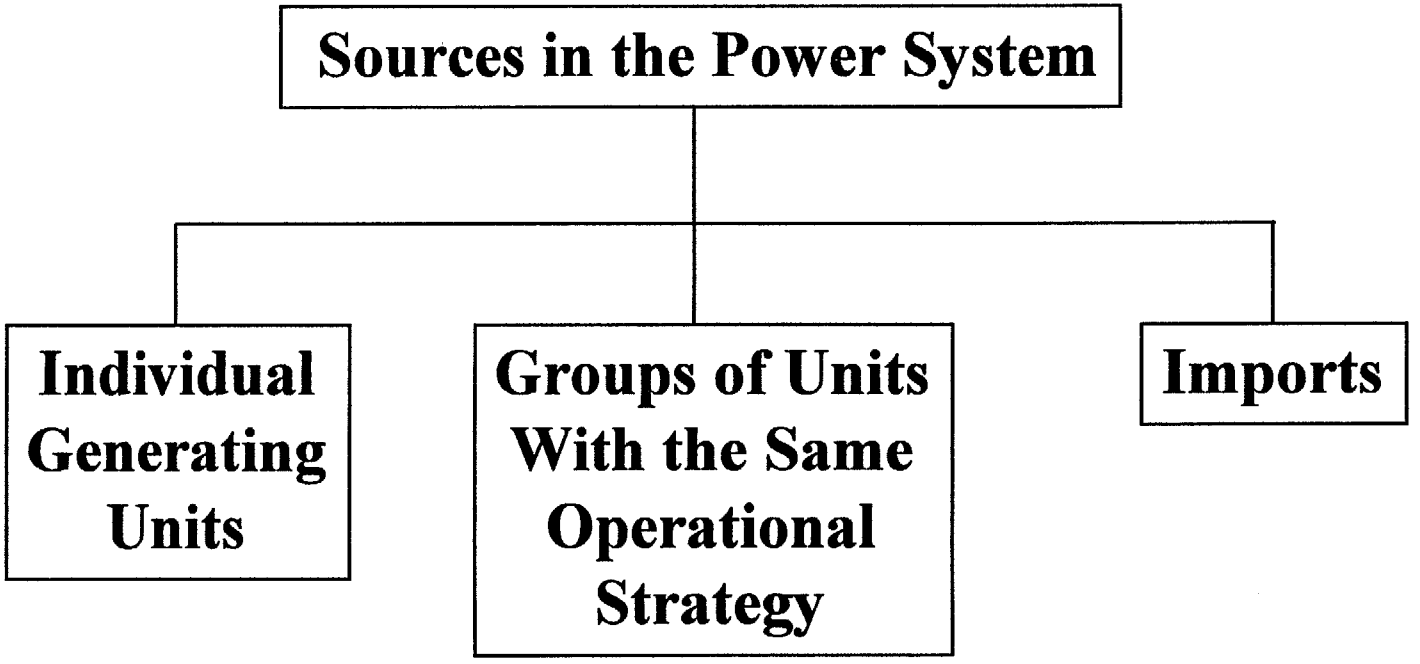
- Electricity consumption
- Future price of fuels
- Future availability of plants
- Capital cost
- Construction times
- Changing environmental regulation

Uncertainty (continued)

Techniques for analyzing uncertainty

- Sensitivity analysis
- Scenario analysis
- Decision analysis

ELFIN Input for the Generating Units



Individual Generating Units

- EBO , EMO
- EVO1 , EVO2
- ENOA , ENOB
- VE Gabcíkovo
- PPC Bratislava, Senné, Kosice, Zilina, Martin, Ziar, Presov, Vojany
- Combustion turbine

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Groups of Units With the Same Operational strategy

- Industry-owned plants
- Distribution companies plants + Heating plant Kosice
- The Vah cascade
- Other hydro plants

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Imports

- Imports are defined by the contract, e.g. size, timing, price are defined

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Input Data for Individual Units

- Data for capacity and specific energy consumption
  - Pmax, Pmin, and significant capacity levels in between, and specific energy consumption for defined capacities
- Other plant characteristics
  - Forced outages
  - Planned maintenance
  - Heat delivery
  - Other restrictions

Input Data for Individual Units (cont.)

- Production Restrictions
  - Fuel limit
  - Time Limit
  - Emission Limit
  - Weekend must-run requirement
  - Daily must-run requirement
  - Fast-start option
  - Operation in given time
- Cost Data
  - Variable operation and maintenance cost
  - Fuel cost

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Input Data for Groups of Units

- Data for capacity and specific energy consumption
  - Dispatch of industry-owned plants under the load duration curve is defined with the specific energy consumption
- Other characteristics
  - For a given capacity - by time period
  - In other case is defined by
    - Forced outages
    - Planned maintenance
    - Heat delivery
    - Other restrictions

Input Data for Groups of Units(cont.)

- Data for production restrictions
  - Same as for individual units
  - Given by defined time period for a whole group of units

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Additions for Variant 1

Year (start of operation)								
1997	1998	1999	2000	2001	2002	2003	2004	2005
Rehab.				Rehab.		GCC		GCC
EVO1				EVO1		Bratislava		Kosice
Unit 5,6				Unit 3,4		200 MW		200 MW
LOLP (days/year)								
0.02	0.02	0.02	0.02	0.02	0.06	0.03	0.09	0.09

Additions for Variant 2

Year (start of operation)								
1997	1998	1999	2000	2001	2002	2003	2004	2005
	Retire			GCC	GCC	GCC	GCC	GCC
	EVO 1			Bratisl.	Kosice	Presov	Ziar	Senne
	Units 3-6			200 MW	200 MW	150 MW	150 MW	70 MW

LOLP (days/year)								
0.03	0.03	0.06	0.12	0.07	0.06	0.05	0.04	0.09

Results for Variant 1 and 2

Sensitivity analysis for investment cost

Investment costs for Vojany 1 mil. Sk		Present Worth Variant 1 (rehab. of Vojany 1) mil. Sk	Present Worth Variant 2 (retire Vojany 1) mil. Sk
4 300	66 %	131 200	
6 450	100 %	132 400	131 100
8 600	133 %	133 600	

Results for Variant 1 and 2

Sensitivity analysis for fixed cost

Fixed costs for Vojany 1 after rehabilitation	Present Worth Variant 1 (rehab. of Vojany 1) mil. Sk	Present Worth Variant 2 (retire Vojany 1) mil. Sk
100 %	132 400	
80 %	131 600	131 100
60 %	130 850	

Additions for Variant 3

Year (start of operation)								
1997	1998	1999	2000	2001	2002	2003	2004	2005
		Retire	GCC	GCC	GCC	GCC	GCC	GCC
		EVO2	Bratisl.	Kosice	Presov	Senne	Ziar	Vojany
		Units5-6	200 MW	200 MW	150 MW	70 MW	150 MW	300 MW
LOLP (days/year)								
0.03	0.03	0.14	0.10	0.09	0.08	0.11	0.09	0.03

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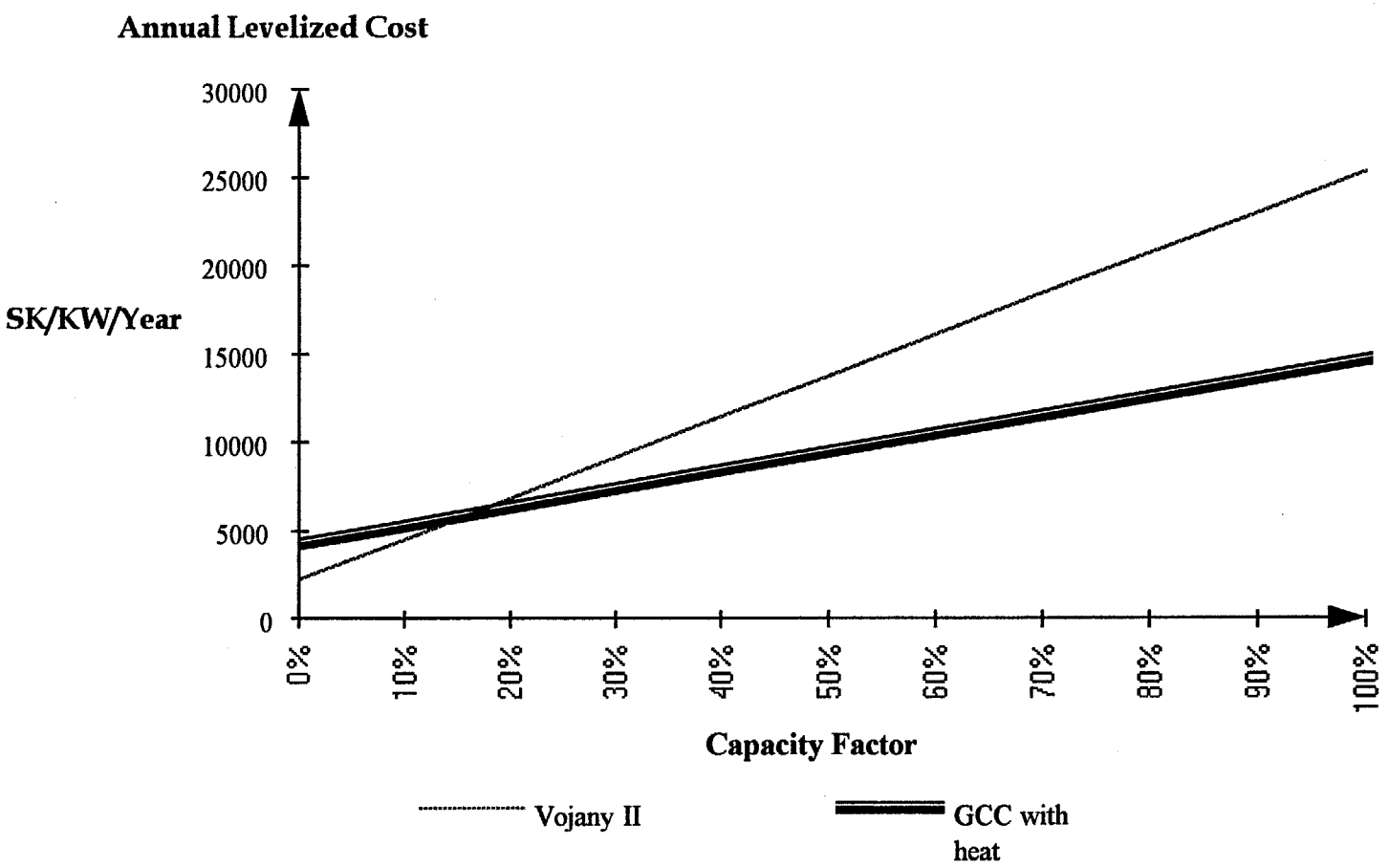
Screening Analysis



Results for Variant 2 and 3

Present Worth	
Variant 2 (contin. operation of Vojany 2 units 5-6) mil. Sk	Variant 3 (all new GCC) mil. Sk
131 100	131 000

Additions for Variant 4

Year (start of operation)

1997	1998	1999	2000	2001	2002	2003	2004	2005
			Imports	GCC	GCC	GCC	GCC	GCC
			1 or 2	Kosice	Presov	Senne	Ziar	Vojany
			170 MW	200 MW	150 MW	70 MW	150 MW	300 MW

Imports 1 - 1.5 Sk/kWh economic loading order with fixed costs

Imports 2 - 1 Sk/kWh base loaded contract

LOLP (days/year)

0.03	0.03	0.14	0.10	0.09	0.08	0.10	0.09	0.03

Results for Variant 4

Present Worth	
Import 1 (economic loading order with fixed charges) mil. Sk	Import 2 (base load without fixed charges) mil. Sk
129 400	130 900

Comparison of Variants

	Present Worth (mil. Sk)
Variant 1 (rehab. of Vojany 1)	132 400
Variant 2 (continued operation of Vojany 2)	131 100
Variant 3 (all new GCC)	131 000
Variant 4 (Import 1)	129 400
(Import 2)	130 900

Summary and Conclusions

- Need to continue to strength energy planning capabilities
- Uniform approach to energy data collection
  - clear definitions
  - confidentiality
- Least emphasis on petroleum sector - market forces
- Most emphasis on power sector
  - magnitude of investment decisions
  - affects all other sectors
  - natural monopoly characteristics
- Use of the ELFIN model is a start.

Attachment B

Energy Workshop and Final Presentation
List of Participants

	Energy Workshop September, 1993	Final Presentation December, 1993
USAID		
Marian Krško	x	x
Ministry of Economy		
Imrich Szitas		x
Bernard Sestrienka	x	x
Milan Špak	x	
Jozef Turza	x	
Marianna Vrbová	x	
Eva Vaňurová	x	
Viera Daubnerová	x	
EGU		
Jozef Šellej		x
Karol Dvorák	x	
Maria Svobodová	x	
Alena Šalamonová	x	
Vladimír Mokrý	x	
Karol Kováč	x	
Jozef Watzka	x	
Ladislav Bíro	x	
Argia Popovičová	x	
Gabriela Zelenaková	x	
Vladimír Čunkerlík		x
Stanislav Ružička		x
VUPEX		
Anton Darmo		x
Peter Belovič		x

	Energy Workshop September, 1993	Final Presentation December, 1993
SEP		
Jozef Ursíny	x	x
Libor Fronc	x	
Maria Mlejová		x
Pavel Jančovič		x
ZSE		
Charvat Zla		x
Michal Mednanský		x
SSE		
Vladimir Mošat		x
Miroslav Rapsik		x
VSE		
Pavol Canga		x
Nuclear Regulatory Authority		
Stanilav Novák		x
SPP		
Lubomir Selc	x	
Eva Malisková		x
Mária Hromská		x
Slovnaft		
Pavol Parák	x	x
Antimonopoly Office		
Andrej Julis		x

	Energy Workshop September, 1993	Final Presentation December, 1993
Dolina Mine		
Martin Hubor	x	
Dušan Lestner	x	
Kamil Rény	x	
Handlova Mine		
Ladislav Mokrý	x	
Ľudovít Zaťko	x	
Peter Skacky		x
Hydroenergia		
Vladimir Ondrušek		x
INCO		
Peter Čertik	x	
National Assoc. of Energy Service Companies (U.S.)		
John Armstrong		x
Southern Electric International		
Bill Winston		x
Bechtel		
Miljenko Bradarić	x	x
Floyd Davis	x	x
Wayne Mikutowicz	x	x

Attachment C

SCENARIO ANALYSIS AND INSTITUTIONAL TASK WORKING PAPER

Introduction

This task is part of a multi-task assignment to assist the Government of Slovakia (GOS) in the development of its energy planning process. The assignment took place during the period July 20 to August 20, 1993. The basis for this assistance is the Energy Concept Report (ECR), prepared by EGU, drafted in April 1993 and revised in June 1993.This report was accepted by the government on August 17, 1993.

The purpose of this task is to provide guidance with respect to the development and use of scenario analysis in the energy planning process. In addition a secondary objective is to make recommendations concerning the institutional requirements regarding energy planning. During the course of this task interviews were held with the following Ministries, Departments and Institutes:

- Ministry of Economy
  - Department of Fuels and Energy
  - Department of Financial Policy
  - Department for Strategy and Economic Policy
  - Department for Budget
- Ministry of Finance - Department of State Budget
- Economic Research Institute
- VUPEX (formerly the Fuels Research Institute)
- Power Research Institute (EGU)

The balance of this working paper addresses the following areas:

- Role and Purpose of Scenarios
- Developing Scenarios
- Review of ECR Scenarios
- Scenario Guidelines for Slovakia
- Institutional Requirements
- Conclusions

The Role and Purpose of Scenarios

Scenarios in their most basic form are intended to portray future outcomes under alternative situations. Scenarios serve two main purposes. The first is protective: anticipating and understanding uncertainty. The second is strategic: understanding what long term options are available. Scenarios can effectively organize a variety of seemingly unrelated economic, technological, competitive, political, and societal information and translate it into a framework for judgement. In other words,they provide a logical basis for dealing with those external forces which are beyond the control of the analyst. However, in order to do this and be defensible scenarios should be internally consistent in the relationships among the key variables.

Scenarios are important because they provide insight to key decision makers. They influence their perception of the future. They become a powerful tool in the planning process. Because decision makers tend to operate under a set of preconceived assumptions, they will make decisions based upon these notions. Accordingly, if they are not informed about the changing external environment they are capable of making incorrect judgements not because of poor strategic reasoning, since this is based on their construct of the future, but because of problems of perception. Scenarios therefore give decision makers something very important - the ability to re-perceive reality. This is of particular relevance when there are turbulent economic conditions as now exist in Slovakia.

Scenario Development

The development of scenarios must be a collaborative effort of both the key decision makers and the analyst. It is impossible to develop a set of scenarios without a knowledge of the key decision makers deepest concerns and their vision of what is to be achieved. In the current situation, this vision is basically the strategic goals for the energy sector. Identifying these concerns and strategic vision can be developed through a structured interview process. Accordingly, this should be the first step in the scenario development process.

The second step in the process is to analyze the economic and energy situation and to crystalize the findings in a set of scenarios. These scenarios should be used to understand how energy consumption patterns will change in the future as the market structure evolves. The analysis phase should attempt to identify the key forces driving the economic-energy system. The interrelationship among these forces should also be examined closely since unexpected events may result from these relationships.In addition any discontinuities in historic trends should be identified and evaluated as to the underlying reasons. Lastly it may also be useful to postulate improbable developments to illuminate the impact on the analyzed relationships.

The principal elements to be evaluated and analyzed can be classified into external factors and internal factors. External factors are those forces outside the energy sector which will have some impact. The most obvious of these would be the impact of changes in personal income levels on aggregate energy demand. Internal factors are those forces which operate within the energy sector such as nuclear power development. It is important to note here that the analysis of these factors will probably not result in a single point value but more likely in a range of values or alternatively provide some insights which then can be used to draw conclusions about other factors. A suggested list of these factors would at a minimum consist of the following as shown in the table below.

EXTERNAL FACTORS	INTERNAL FACTORS
- Fiscal and Monetary Policy	- Import Prices
- Aggregate Price Levels	- Conservation
- Investment	- Environmental Regulations
- Unemployment	- Nuclear Policy
- Personal Income	- Technology Changes
- Government Expenditures	- Security of Supply
- Industrial Output	- Regional Energy Situation
- Privatization	- Energy Investments

The end result of the evaluation of the external factors will be embodied in three key parameters - GDP, income levels, and prices, while the evaluation of internal factors will result in the identification of possible energy market configurations. The linkage between the external macroeconomic factors and aggregate and/or sector energy demand is usually handled through the estimation of income, price, and output (GDP) elasticities.

The final step then is to utilize this information and the insights gained to construct the possible scenarios by developing hypotheses which result in a few alternative and internally consistent pathways to the future. As a guide three scenarios are usually sufficient and probably not more than four as this will tend to confuse the decision makers ability to see things clearly. The objective is to have a set of scenarios that illuminate the major forces driving the system, their interrelationships, and the critical uncertainties.

Review of the ECR Scenarios

The purpose of this section is twofold:

1) To describe the scenarios presented in the ECR
2) To evaluate the scenarios as to their scope and internal consistency

Description of Scenarios: The ECR is a long term energy plan with a time horizon of fifteen years, the terminal year being 2010. In the ECR three alternatives were developed

and these formed the basis for all subsequent analysis of sector fuel shares and energy supply. These alternatives were apparently developed with two strategic objectives in mind. As stated in the ECR "Energy should be:

- generated at the lowest cost and the lowest ecological impact
- transported to the consumer safely and reliably"

The resultant cases are described below.

Alternative 1 (Basic Case):

The major driving factors are the assumptions with regard to electric power resources- in particular nuclear power resources. The base case assumes NP Bohunice will be deactivated in 1995 while NP Mochovce will be phased over the period 1994 - 1997. It is also assumed that fossil plant Vojany units 3-6 will be repowered and Novaky will be rehabilitated. This case also assumes greater use natural gas and increased use of hydro resources.

Alternatives 2 and 3:

The major differentiating factor in these two cases are the assumptions regarding the deactivation of Bohunice and the phase in of Mochovce. In alternative 2 Bohunice is kept in operation until 2000, everything else remains the same. In Alternative 3 Bohunice is kept in operation until 2005, and the phase in of the last two units of Mochovce are delayed until 2005-2006.

There are a number of other factors which were analyzed but their linkage to the above cases is not clear in reading the ECR. These other driving factors are as follows:

Economic Growth-

Two forecasts of GDP were developed by the Economic Research Institute and referenced in the ECR. The forecast reviews economic development in Slovakia and three basic assumptions are made:

1) Money supply will stabilize
2) Devaluation of the Slovak crown will be minimal
3) The GOS will remove any legal or regulatory impediments to private enterprise

In addition the industrial sector was analyzed as it accounts for over 50 percent of GDP. Accordingly, forecasts were developed for fifteen sectors including industrial, agriculture, energy, trade, construction, transport and services. The results show a major shift in sector contribution to GDP by industry dropping from 60% of GDP in 1990 to 45% in 2010. The service sector will almost double in its share of GDP to almost 20% by 2010. The balance of the sectoral changes are

spread across the remaining sectors. The development of these forecasts is based on a comparison with a test group of countries which are believed exhibited similar economic development patterns and have comparable characteristics. These countries include Denmark, Sweden, Norway, Belgium, Finland, and the Netherlands. The resultant forecasts of GDP indicate that the bottom of the economic cycle should be reached in 1994, with positive economic growth thereafter. The forecasts of GDP are set out below.

GDP Forecast for Slovakia
(constant 1990 SK, billions)

YEAR	1990	1995	2000	2010
GDP Case A	232	178	205	282
GDP Case B	232	166	175	203
Growth Rate A	(5.2%)		3.1%	
Growth Rate B	(6.4%)		1.4%	
	1990-95		1995-2010	

Other Factors -

In the ECR several other factors were identified as having an impact on the prospective outlook for energy in Slovakia. Underlying all of these is the assumption of a viable market economy. Among other things, this is taken to mean competition in energy markets. In fact, this assumption is stated in the ECR as a major distinguishing element from the previous years ECR. Based on the classification system set out above all of these factors, with the exception of the last, could be considered internal factors. These are as follows:

- Security of supply with allowance for imports of electric energy up to 20%
- Reduction in energy demand through productivity increases and conservation
- Utilization of renewables and secondary sources of energy
    - Extensive use of cogeneration and combined cycles
    - Reduction in uneconomic generation resources
    - Energy prices should reflect underlying economic and financial costs
    - Environmental- reduce SO2 emissions by 30% of 1990 levels by the end of 1993
    - Promote access to foreign capital

Evaluation of Scenarios: In order to gauge the usefulness and viability of the scenarios the starting point is to look at the forecast of total primary energy supply (TPES) under each of the scenarios. However, in the ECR only one forecast of TPES is set out so its relationship to the scenarios is unclear. This should be considered a major deficiency. Accordingly, it accomplishes none of the goals of a well developed scenario as discussed previously.

There are other elements which one would expect to find in the development of the scenarios but are not set out explicitly:

- There are no assumptions or forecasts regarding world crude oil prices
- There are fuel price forecasts but no linkage to costs
- There is no evaluation or forecast of income levels

All of the above are important in developing relationships between economic activity and energy consumption. In the Slovak Republic there have been significant changes in incomes and prices, therefore it is important that the effects of these two elements be estimated to assist policy makers in evaluating their impact on economic performance and energy demand. Moreover, the Slovak Republic is in a transition period where energy prices will continue to increase. Accordingly, scenarios which contain no explicit cost, price and income relationships cannot provide a realistic assessment of energy demand and supply.

Given the above it is difficult to gauge the logic and internal consistency of the scenarios. However an attempt is made by setting out some key indices, some of which were estimated, as shown in the table below:

ECR SCENARIO ANALYSIS

YEAR	1990	1995	2000	2010
TPES (PJ)	945.3	822	901	1000
TPES Growth Rate	(2.8%)		1.3%	
	1990-1995		1995-2010	
Gas Share TPES	24%	27%	28%	35%
TPES Intensity Case A (TPES/Billion SK GDP)	4.07	4.62	4.40	3.55
TPES Intensity Case B (TPES/Billion SK GDP)	4.07	4.95	5.16	4.93
TPES per Capita	178.3	152.2	166.8	181.8
GDP/Capita (1990 SK, thousands) Case A	43.8	43.4	37.9	52.3
GDP/Capita (1990 SK) Case B	43.8	31.3	32.3	37.6
Energy Independence (domestic prod./TPES)	11%			6.2%

As can be seen from the table, TPES declines significantly through 1995 and then exhibits slow growth to 2010. The rate of decline is lower than either of the GDP forecasts while the rebound is in tandem with the lower forecast (case B) of GDP. Over this period gas increases its share of TPES significantly, so underlying this plan is an implicit plan to become a gas-based economy. This is consistent with the other factors considered in the ECR as discussed above. However there is no explicit analysis of the economic implications of such a dramatic shift in supply.

Energy intensities are also estimated in the above table for each GDP forecast. In absolute terms it should be noted that Slovakia has one of the highest energy intensities in comparison to Western countries and some Eastern European countries. As a consequence, the ECR places a heavy emphasis on the effects of conservation. However, the table shows that energy intensity increases under both cases over the entire period with the exception of case A in 2010 when it declines significantly. This is attributed in the ECR to structural changes in the economy and the effect of energy savings programs. However, considering the overall trend in energy intensities the results are difficult to reconcile. We know from the economic forecast that the structural changes occur throughout the period. Furthermore as the TPES forecast looks more in line with

the lower economic forecast (case B) energy intensities increase continuously. One possible explanation is that under case B the restructuring process takes longer and there is less investment hence energy intensities increase. Assuming this situation it would also indicate that over the 15 year forecast period:

1) Marginal industries continue to operate but at a lower level of output
2) Prices and Tariffs do not reach market levels
3) There is no investment in energy saving technology or conservation programs

While all of these are possible, in reality they seem unlikely. Moreover this situation stands in contradiction to the other factors, discussed above, which guided the direction of the ECR. Logically, then one would expect to see a decline in the energy intensity indicators throughout most of the period. Thus the internal logic appears to be a problem or alternatively it may imply that the TPES was overestimated.

Lastly, one of the guiding factors in the ECR was a security of supply considerations. As the table above indicates, in contrast to this factor, energy dependence will continue to increase over the period. This is due to the significant increase in gas use. Given this situation, the risks and costs associated with such a strategy should have been part of the scenario analysis.

In summary the scenario analysis contains a number of deficiencies which limit their value significantly. On a more general level they insufficient because they do not present alternative visions of the future as discussed above, rather they are variations on a single theme.

Scenario Guidelines for the Future

The purpose of this section is not to develop complete scenarios but rather to suggest possible alternative scenario descriptions that could be considered in the development of the next ECR. As indicated to the project team the ECR is considered "living document" which will evolve over time to include new techniques and methods.

The table below outlines possible scenarios for future consideration.

POSSIBLE SCENARIOS

Scenario

	Economic Outlook	Rate of Structural Change	Energy Import Prices	Gas Share TPES	Coal Share TPES	Nuclear Availability	Environmental Program	Conservation Program
A	Good	Fast	Low	High	Low	High	Strong	Strong
B	Good	Fast	High	High	Low	Low	Strong	Strong
C	Moder-	Moder-	Moder-	Low	High	High	Strong	Strong
D	Poor	Slow	High	High	Low	Low	Strong	Strong
E	Poor	Slow	High	Low	High	Low	Weak	Weak

The above table portrays five possible scenario constructions in terms of key parameters and their relative level of activity. Obviously, in the development of the actual scenarios each element would be the subject of analysis as well as the interaction among them. The scenarios are described below:

Scenarios A and B - These could be considered optimistic visions of the future where the Slovak economy quickly resumes economic growth.In this scenario one might envision a resumption of growth starting in 1994. Energy import prices low and a shift to gas is anticipated. There are aggressive environmental and conservation programs. In addition maximum use is made of nuclear resources in one case but not the other. In this case (B) even more gas is used. The key issue then is how stable is such a situation- is it sustainable. Will it lead to major dislocations in the economy- possibly resulting in cyclical downturn? What will happen to end-user energy prices. What are the risks associated with the sources of gas supply? And, what are the costs associated with this type of development?

Scenario C - This a moderate case with heavy emphasis on energy security by maximum use of coal and nuclear resources. It would require investment in clean coal technologies. The key issue revolves around the cost of achieving this level of security and the resultant impact on end-use energy prices.

Scenarios D and E - These are considered contingency scenarios that consider the worst of all possibilities. In contrast to scenarios A and B, the resumption in economic growth might not commence until 1997. The issue here is whether they are indeed plausible and what they portend for future capacity requirements.

The above scenarios present alternative views of the future, and show how the relationships among key parameters can be developed. There are many issues which will

surface during the course of evaluating these scenarios which ultimately lead to decisions about their viability. Lastly, it should be noted that while five scenarios are displayed not all of them would be presented in the final analysis. Some would be discarded as simply being implausible. Nevertheless these must be analyzed before such judgements can be drawn.

Recommendations

The following recommendations emerge from this task:

1) The use of scenario analysis should continue to be refined and expanded. In particular the scenarios need to be better developed and more clearly described. There should also be an explicit specification of the key parameters such as income changes, changes in the overall level of prices, GDP, energy costs, and prices to better understand how these factors interrelate in their impact on the economy, energy mix, and energy policy.

2) The implications of the scenario analysis should be clearly stated in the beginning of the ECR with respect to the scope and emphasis of energy policy.

3) Because scenario analysis by its nature can become quite complex, greater use of simulation and other planning models would permit a more comprehensive method to evaluate the interrelationships among the range of parameters.

4) A uniform approach to collection of energy data should be developed, including the development of energy balances, which will facilitate the analysis of energy and economic relationships.

Attachment D

COAL SECTOR WORKING PAPER

1.0 INTRODUCTION

This report summarizes a review of the Coal Sector of the Slovak Republic. The purpose of this review is threefold;

1) To determine the need for technical assistance in this Sector
2) To recommend areas in need of further study
3) To review and comment on the Coal Section of the Energy Policy Statement based upon what has been learned during the course of this review

The author expended two weeks in this effort. This time was spent in planning (15%), interviews with staff members at the Ministry of Economy and EGU (20%) on-site inspection of the Zahorie Mine and the Handlova Mine (20%), review of the documents supplied by the Ministry, the Mines, EGU and Bechtel (20%), and report writing, review and translation (25%). This should be considered a conceptual analysis as time was insufficient to review any element in depth. All parties to this effort were extremely helpful and knowledgeable including Bechtel, the translators and the Slovak professionals at the Ministry,EGU and the Mines.

This report will not present all of the detailed data gathered and reviewed during this effort. This information is already documented in various studies at the Ministry and EGU. This data will be presented in summary form and the major findings will be discussed. Information gathered from interviews and not observed in written reports will also be presented.

2.0 SUMMARY AND FINDINGS

The coal industry in Slovakia has undergone changes in its commercial structure. Reflecting the location of the coal deposits and markets the industry has been restructured on a geographic basis. This has resulted in the formation of three mining districts:

- Horna Nitro District
- Modro Kamenske Loziska District
- Zahorie District

The coal mining sector consists of five (5) mines in these three (3) mining districts; the

Zahorie Mine in the Zahorie District, the Handlova, Cigel and Novaky Mines in the Horna Nitro District and the Dolina Mine in the Modro Kamenske Loziska District. These are all located 80 to 150 kilometers northwest of Bratislava in eastern West Slovakia and western Central Slovakia. They are all underground longwall operations and in the Horna Nitro district they also use room and pillar methods. The output of these mines are brown coals, ranging in average seam thickness from two (2) meters to seven (7) meters, in average depth from 130 meters to 420 meters and in heating valve from 10 MJ/kg (4303 Btu/lb) to 17 MJ/kg (7315 Btu/lb).

Mining operations in each district are controlled by a State Owned Enterprise. It is expected that early in 1994, the next phase of the coal industry's restructuring will occur when the Zahorie and Modro Kamenske Loziska District Enterprises become joint stock companies - thus paving the way for eventual privatization. The Horna Nitro District Enterprises will remain under State ownership.

Current total production from these mines is about 3.5 million metric tonnes per year. The power plants at Novaky consume 2.5 million tonnes, District Heating Centers consume about 100 thousand metric tonnes per year and about 800 thousand metric tonnes of sized coal is consumed in residential and commercial heating. Total production capacity of theses mines, utilizing existing equipment and facilities,considering physical mining constraints and without significant new investment is 4.2 million tonnes per year.

Table 1. Summary of Mine Statistics

Mine Name	Seam Thickness (Meters)	Heating Value (MJ/kg	Sulfur Content (%)	Ash Content (%)	Water Content (%)	Production (000's) 1992	Employees (No.) Total
Zahorie	4.6	10.52	1.20	18.44	44.35	89	310
Handlova	4.9	16.91	1.52	21.38	20.18	855	2488
Cigel	4.5	12.55	2.46	30.35	22.55	810	2810
Novaky	6.9	11.65	3.81	23.87	34.46	1170	2901
Dolina	2.1	12.29	3.49	30.01	27.68	596	1582
Total						3520	10091

1. mt = metric tonnes (x 1.12 = Short tons)
2. Production ability without large additional investment

The technical ability of the Slovak mining geologist and engineers appears to be similar to these professions in the United States. Visual inspection of the mine at Zahorie shows an operation generally similar to US underground longwall operations with the exception of geologic conditions and safety procedures. Inspection of the mine at Handlova shows an operation with extremely difficult mining conditions in all respects. Nothing this severe is undertaken in the U.S. Labor productivities range from 304 mt/yr/man at Handlova to 830

mt/yr/man at Zahorie. This compares to US total underground mines at about 5000 mt/yr/man and about 8000 mt/yr/man at west US underground longwall mines. Labor cost compare at about 1805 k/mt or 24% of total cost in Slovakia to about $7/tonne or 30% of average sales price in the U.S.

The following findings and recommendations are made:

1. Both countries (U.S. and Slovakia) might gain from a technical exchange. The US. mining industry and the Slovak mining industry have each had unique problems to solve over their history. The methods developed to operate under these conditions (geologic) might benefit the other in specific problem areas. This exchange should take place between professional trained in underground mine engineering. The exchange would consist of a U.S. engineer inspecting the Slovak mines at Handlova, Novaky and Dolina and a Slovak engineer inspecting mines in the Appalachian region, the Illinois Basin, the Green River Basin and the Raton Basin.

2. The mine visit did not entail a comprehensive safety review. Some modifications might be considered in this area which would not require significant capital investment. Inspectors for the World Bank or from the U.S. Regulators (MSHA, OSHA) might find these issues significant. These include the following:

    a) Visitors (such as myself) were not certified in the use of the Miners Safety Kit.

    b) Visitors were not instructed on the location of Safety Stations underground or the mine layout and the direction of primary and secondary escape routes.

    c) Underground corridors did not have reflectors which make the primary and secondary escape routes obvious.

    d) Safety glasses and steel-toe boots were not required.

3. It is uncertain, to what degree, pre-combustion clean coal technologies have been evaluated. There appeared to be a lower level of understanding of these technologies than there is of the combustion technologies or post-combustion technologies, which appear to be well understood. This may be of secondary importance however, for the following reasons:

    a) Compliance plans for the Novaky units have already been determined and construction is in progress. Novaky A will be repowered as a fluidized bed boiler, Novaky B will use post-

combustion clean-up technology and Novaky C will be idled.

b) These new clean coal precombustion technologies are still being perfected under the Clean Coal Demonstration Program. While there are some commercial discussions underway (Rosebud SynCoal Partnership - ACCP) most will not be ready for commercial development for several years. The intent of the demonstration program is to prove the technologies and decrease construction and operating cost through operating experience with demonstration scale projects which are about 50% of commercial scale. It is recommended that these technologies be investigated to determine any potential application for the Slovak Mining Sector.

4. It is our understanding that most of the fuel research is done at the Fuels Research Institute of Prague. This includes both research of Combustion Technologies (and presumably Clean Coal Technologies) and also is the laboratory where coal is analyzed for its ash constituents and behavior of its elemental constituents. The power plants only do proximate analyses (moisture, ash, sulfur, heating value). This is acceptable, provided that Slovakia has access to this laboratory, and all of its research results, at reasonable costs. It is possible however, that this Institute could develop methods, through its research, that would give the Czech Republic a competitive advantage, which would not be extended to the Slovak Republic.

5. The Slovak mining business might benefit from exposure to U.S. methods of market research in the area's of market pricing and competitor analysis. For example, it seems to be presumed that Central and Eastern Europe coal and transportation prices will eventually rise to wester Europe levels, this is not necessarily true. The costs of production will vary depending on the production factors in different regions, such as the costs of fuel, electric power, labor rates and productivities, supplies, equipment productivity and etc. The cost of electric power, for example, ranges from $0.06/kWh in the northwest U.S., where hydro and coal are used, to $0.15/kWh in the northeast US, where oil and nuclear are used. Knowing a competitor's costs of production and excess production capacity may help to determine how it will price its product.

   Government agencies in the U.S. (such as FERC) and some private companies (RDI, King's, Coal Outlook) collect and report delivered prices to U. S. utilities and to port facilities worldwide. This data can be used to estimate competitors market prices at the mine by estimating transportation rates. There are various methods and sources enabling estimation of transportation rates.

6. Labor productivities in Slovakia are extremely low relative to the U.S. This appears to be primarily due to the operating requirements of very different geologic conditions, The Slovaks are underground mining a low quality (brown coal) coal, in unconsolidated, water saturated overburden and underburden material. Roof support, dewatering, depressurization, dust control and ventilation require labor intensive efforts,. Manpower levels at the longwalls are also higher than the U.S. by a factor of 2 to 3 times and are probably due to different levels of automation and geologic differences. In spite of these productivity differences, the Slovak labor cost per tonne as a percent of total cost is similar to the U.S. (25-30%).

7. The Zahorie Mine is a new and modern operation with relatively easy mining conditions when compared to the other mines at Handlova, Dolina, Novaky and Cigel. It is about 50 km west of the Novaky Power Plant and its only market is about 150 thousand tonnes per year to local district heating centers, industrial and residential heating. Long term operation of this mine will require these local markets to comply with air emission requirements through FBC repowering or post combustion clean-up rather than fuel switching. Alternately, Zahorie would have to ship coal to the Novaky units where there will already be an oversupply from the other mines closer to Novaky.

8. The Handlova Mine is operating in extremely adverse conditions. There is about 12 million metric tonnes of additional recoverable reserve remaining without significant investments in mine expansion. The mine can produce about 900 thousand tonnes per year without significant investment in production capacity. Consumption at Novaky will drop from about 2.3 million tonnes today to about 1.5 million tonnes in 1999 when Novaky C is retired. The mines at Novaky,Cigel and Dolina have combined recoverable reserves remaining of about 50 million metric tonnes and an annual production capacity of about 3 million metric tonnes, both without significant new investment.

9. Based on this review it appears that the economics of domestic coal production are marginal at best. The significant incremental investment required to expand and modernize production may be difficult to justify. However given the fact that coal is the only domestic resource aside from hydro and has important impact on employment in specific regions, future work should attempt to quantify the full economic cost, including the use of appropriate shadow prices and consideration of environmental factors - of continued use of domestic coal vis-a-vis imported coal or gas.

Coal demand in the Slovak Republic is from electric generating stations, district heating centers, industrial boilers and residential boilers, combined these consume 15 million metric tonnes per year of which about 3.5 million metric tonnes is produced in Slovakia and about

11.5 million metric tonnes is imported from the Czech Republic and the CIS.

The electric generating stations consist of the Novaky units A, B, and C and the Vojany Station. Novaky A is two 110 MW units that are planned for retrofit to fluidized bed boilers. Novaky B is also two 110 MW boilers and is installing scrubbers. The Novaky C units are also two (2) 110 MW units and are planned for retirement in 1998. Together, the Novaky units consume about 2.5 million metric tonnes of Slovak brown coal from the mines at Handlova, Novaky, Cigel and Dolina and minor quantities from Zahorie. When Novaky C is retired, consumption will drop to about 1.5 million tonnes per year.

The Vojany coal plant is a 6 x 110 MW station that consumes about 1.4 million tonnes per year of bituminous coal from the CIS. This coal is 24 MJ/kg and two (2)% sulfur. Compliance plans for this station are undetermined but both switching to a compliance CIS coal and repowering to gas combined cycle are under consideration. The station is near the gas transmission system but there is concern about long-term gas supply and price and the investment required for repowering. Supply and price are also a concern with imported coal and NO_x may be difficult to control for these CIS compliance coals.

The district heating centers consume about 1.4 million tonnes of coal per year. This is imported CIS coal (500 thousand tonnes), imported brown coal (750 thousand tonnes), and domestic brown coal (100 thousand tonnes). Compliance plans in this sector are not finalized but these stations have been slowly switching to natural gas. Because these are smaller stations (under 50 MW), and have low load factors, it is likely that they will continue switching to natural gas and some may switch to imported compliance coal. Significant investments in technologies to control emissions are unlikely. Socioeconomic costs and the risk in price and supply of imported fuel may favor continued utilization of domestic brown coals for those stations located close to the existing Slovak mines.

Slovak industry consumes about 4.2 million tonnes annually plus about 2.8 million tonnes of metallurgical coal. Direct residential and commercial use is about 3.3 million tonnes annually. Most of this residential, commercial and industrial coal (except the coking coal) is imported brown coal. It is speculated here that much of this imported brown coal use will eventually switch to natural gas or compliance coal for the same reasons as discussed above for the district heating centers.

Tables 2 and 3 below summarize the current and projected coal utilization discussed above. The source of this data is discussions with mining and utility experts at the Ministry of Economy and EGU and the authors assumptions form these discussions. These assumptions lead to projected year 2000 coal utilization very similar to those projected in the Energy Table 15a. Those assumptions are:

1) The trend of district heating centers switching to gas will continue as these stations comply with new emission requirements. Some district heating centers near domestic mining operations will continue using domestic coal

(50%) and 50% will switch to gas.

2) Those industrial and district heating centers using imported brown coal will switch to gas (75%) and imported compliance coal (25%).

3) Those residential and commercial customers using domestic brown coal or imported coal will switch to gas.

These assumptions are not based on a rigorous under-standing of the Slovak infrastructure but rather are speculations based on investment difficulties, risk of foreign price and supply, proximity to fuels and transportation modes (rail and pipeline) and socio-economic impacts.

Table 2. Coal Consumption 1993
Metric Tonnes(000) Approximate

COAL	COKING	DISTRICT* HEATING	INDUSTRY*	RESIDENTIAL COMMERCIAL	NOVAKY/ VOJANY	TOTAL
Hard Coal Imp.	2800	515	515	70	1400	5300
Brown Import	-	750	3150	2300	-	6200
Brown Domestic	-	100	-	800	2500	3400
TOTAL	2800	1365	3665	3170	3900	14900

* Total district heating and industrial are about 1.03 million tonnes for hard coal imports.

Table 3. Coal Consumption 2000
Metric Tonnes(000) Projected

COAL	COKING	DISTRICT HEATING	INDUSTRY	RESIDENTIAL COMMERCIAL	NOVAKY/ VOJANY	TOTAL
Hard Coal Imp.	2500	915	550	70	1400	4300
Brown Import	-	750	3150	2300	-	6200
Brown Domestic	-	100	-	800	2500	3400
TOTAL	2500	1365	3700	3170	3900	14900

The new Slovak air emission standards are summarized on Table 4. These standards are in effect today for all new sources and take effect in 1999 for all existing sources. Today, middle sources are defined as 0.2 MW to 5 MW but will be redefined to 0.2 MW to 50 MW in 1999. This does not affect emission requirements but only changes where payments are directed for emission violations. Emission violation penalties for large sources (above 50 MW) is paid to the federal government. Violations of middle and small sources is paid to district and local governments,. Beginning in 1999, local and district governments will collect penalties for violations of sources in the 5 MW to 50 MW size range. Table 5 shows the emission penalties effective in 1999. These increase gradually from 40% of these values in 1993 to 60% in 1994 and 80% in 1997.

Table 4. New Slovak Air Emission Standards
Coal sources @ 60% Excess O_2
Milligrams/Standard Cube Meter

Sources	SO_2	NO_x	CO	Particulates
5-50 MW	2500	650	250	150
50-300 MW	1700	550	250	100
G.T. 300 MW	500	550	250	100
Wet Bottom Boilers		1100		
Fluid Beds>2MW	500	500	250	50

Table 5. Air Emission Violation Penalties
Sk/metric tonne

SO_2	1000
NO_x	800
CO	600
Particulates	3000

All sources must submit compliance plans to either the local or federal regulatory agencies every two years. With the exception of the Novaky Generating Station, and those district heating centers that have already switched to gas, it is still uncertain how most of these sources will comply. Generally, the small stoker boilers (under 2 MW) already comply with SO_2 limits and only need to worry about particulate emissions. Probably most boilers between 3 MW and 50 MW will either switch to gas or imported compliance coal.

EGU has evaluated compliance options for the middle sources (0.2 - 50 MW) which comprises much of the industrial and district heating sectors. The results of this work show that the most cost effective option for these sources is the utilization of compliance coal from the CIS. These analysis also show that domestic brown coal cannot compete with gas as a compliance option.

EGU has evaluated various options including the following. The results of those studies reviewed indicate:

high ash content and low heating value

2) Fluidized bed technology is better suited to Slovak brown coals than gasification.

3) Electrostatic precipitators will not work with slovak coals due to the high ash loading. Post combustion particulate removal must employ fabric filters

4) Gas co-firing with brown coal improves the economics, but does not remove the need for desulfurization

5) NO_x limits will be difficult to achieve with some CIS coals

3.0 COAL SUPPLY

3.1 Zahorie Mine

The Zahorie Mine was visited on Thursday July 29, 1993. The mine was not operating when viewed. The mine started operations in November 1991 and was a modern and clean facility. The automated control room monitored most underground equipment and activities and the dispatcher had redundant communication channels both underground and to outside emergency services. The control software also accumulated operating statistics.

Geologic reserves are about 66 million tonnes. Mineable reserves are about 42 million tonnes and of this, about 65 percent or 27 million tonnes can be recovered during mining. The disposable reserves, or reserves available without significant investment in mine expansion is about 6 million tonnes. Current production capacity is 400 thousand tonnes per year.

Coal is mined from a single seam that averages 4.6 meters in thickness. The average depth to the seam is 130 meters. The overburden material is unconsolidated fine sands which are water saturated. The sands are dewatered both from the surface in advance of mining and from underground during mining.

Washed and sized coal is sold for local residential and commercial heating. Unwashed coal is sold to local district heating centers and minor amounts to the power plants at Novaky. A total of 150 thousand tonnes were sold during 1992.

Cost data has been difficult to determine. The information presented below is taken from a variety of sources which are submitted with the back-up material for this report. It is undetermined what components make-up these costs and they should be used with caution. Additional work will be required for an accurate determination of mining costs, transportation costs, revenues and income.

780 Sk/tonne -	1993 Brown coal price (9.6-10.5 MJ/kg) including VAT and Transportation. Source: Table 15f
105 Sk/tonne -	1993 Average transportation cost Source: Table 15e
574 Sk/tonne -	1992 mining cost Source: Table BP 38-6-16813
431 Sk/tonne -	1994 Projected mining cost Source: Table c.12
458 Sk/tonne -	1994 Projected revenue Source: Table c.12

3.2 Handlova Mine

The Handlova Mine was visited on Wednesday August 4, 1993. The mine was in operation when viewed. This mine operates in extremely difficult conditions, It started operations in 1912 and has been in operation continuously since that time. It employs approximately 2700 people and has five (5) operating longwalls of 60 meters in width and one room and pillar operation. The mine control center is installing a state-of-the art automated control system which will be functional within two months.

The challenges at this mine include water saturated overburden, extreme overburden pressures, spontaneous combustion of the coal seam and coal dust, methane, and CO_2 ventilation, and transportation times of 40 minutes form the portal to the working faces. The mine runs four (4) shifts per day, five (5) days per week.

Seam thickness averages about 5 meters and the average depth to the seam is 420 meters. Elevation of the seam varies 700 meters within the entire mine complex due to tensional faulting. Geologic reserves are about 63 million metric tonnes. Mineable reserves are 44 million tonnes of which 25 million tonnes are recoverable in mining. About 12 million tonnes are considered recoverable with no significant investment in mine expansion. The annual production capacity without significant investment in equipment and facilities is 900 thousand tonnes per year.

The overburden material is volcanic sediments that are water saturated. Interstratified confining beds make the hydrologic interconnection poor. Therefore dewatering efforts and monitoring are very difficult. Dewatering efforts are both from the surface and underground. These andesite layers are up to 300 meters thick and are separated from the coal by clay. When the clay layer is thinner than 30 meters the coal cannot be recovered due to instability and water seepage from the volcanic sediments.

Roof and entry supports consist of four sections of channeled iron constructed in a circle around the roof, floor and sides of the entries (ring girders). The are sectioned in order to contract by sliding relative to each other rather than fatigue under the heavy loads. These are constructed on about 0.5 - 1.0 meter intervals with roof bolts and a continuous layer of timbers between the ring girders and the coal. This support structure is dismantled as the longwall advances and the materials are transported for use elsewhere in the mine.

Approximately half of the production of this mine (420 thousand tonnes) is washed and sized and sold locally for residential and commercial heating. The remaining 420 thousand tonnes is unwashed and sold to the Novaky power plant (350 thousand tonnes) and the Handlova district heating center (70 thousand tonnes)

The following cost data is presented with the same cautions as previously stated:

700 Sk/tonne -	1993 brown coal price (9.6 - 1.05 MJ/Kg) including VAT and transportation. Source: Table 15f.
1120 Sk/tonne -	1993 wash coal price (16 MJ/Kg) Source: Interview
90 Sk/tonne -	1993 average transportation cost for wash coal Source: Table 15e
700 Sk/tonne -	1992 mining cost/tonne Source: Table BP 38-6-16813
831 Sk/tonne -	1992 revenue/tonne Source: Table BP 38-6-16813
197 Sk/tonne-	1992 labor cost/tonne Source: Table BP 38-6-6813
775 Sk/tonne -	1993 Projected Mining costs Source: Table C.15
668 Sk/tonne -	1994 Projected revenue Source: C.15

3.3 Cigel Mine

The Cigel Mine was not visited. The mine description below is from interview. This mine opened in 1962. Like Handlova there has been faulting and the mine operates on numerous levels and conditions are generally becoming more difficult. The mine

employees about 3000 people, has four operating longwalls, and ten room and pillars and pillars and produces about 750 thousand tonnes per year (1992).

Seam thickness averages 4.5 meters and average depth to the seam is 250 meters. Geologic reserves are 74 million tonnes, of which 50 million tonnes are mineable and about 28 million tonnes are recoverable. Without significant new investment in mine facilities or equipment there are 15 million tonnes remaining with an annual production rate of 900 thousand tonnes per year.

The overburden material is water saturated fine sands separated from the coal by 30 to 40 meters of clay. These sands continue to the surface and are recharged by direct hydraulic connection to surface waters. Dewatering takes place both from the surface and underground. Dewatering is not a serious technical problem, as at Handlova but represents some cost and operating constraints.

Coal from Cigel is sold to the Novaky generating station (470 thousand tonnes 1992) and about 300 thousand tonnes of washed and sized coal (13 MJ/Kg) is sold as stoker fuel for residential and commercial heating.

3.4 Novaky Mine

Novaky was also not visited. This mine was opened in 1942. This is the most profitable of the Slovak mines and is supposedly the only mine making a profit. Interviews disclosed that all mines together operate at close to breakeven with Novaky being profitable and the other four losing money.

Seam thickness at Novaky averages about 7 meters at an average depth of 140 meters. Overburden conditions are similar to Cigel with fine water saturated sands hydrologically connected to the surface waters. Additionally however the sands in the underburden are also water bearing and need to be depressurized during mine development. These underburden sands can buckle the floor. allowing water and CO_2 to enter the mine.

This mine produces about 1.1 million tonnes per year, has six (6) operating longwalls and nine (9) room and pillar operations. The mine employs about 3000 people.

Geologic reserves are about 168 million tonnes of which 59 million are mineable and 35 million are recoverable. Recoverable reserves without significant new investment is 20 million tonnes at an annual capacity of 1.2 million tonnes. All production from Novaky is sold to the Novaky power plant.

3.5 Dolina Mine

Dolina was also not visited. This mine is similar to Zahorie in the overburden material and similar to Novaky in the underburden. Dewatering is not difficult and is done primarily from

the surface two years in advance of mining.

The mineable seams averages 4.5 meters in thickness and mine depth averages 160 meters. Geologic reserves are 54 million tonnes, of which 38 million are mineable and 32 million tonnes recoverable at a production rate of 650 thousand tonnes per year without significant additional investment.

The mine utilizes six (6) longwalls, has about 1650 employees and produces about 600 thousand tonnes per year. The coal is sold to the Novaky Power Plant (540 thousand tonnes unwashed) and about 60 thousand tonnes of washed and sized coal is sold for residential and commercial heating.

Table 6
COST/PRICE DATA
Novaky, Cigel, Dolina

Novaky	Cigel	Dolina	Source
700	675	700	1993 brown coal price Inc VAT and transportation Table 15f
92	90	100	1993 average transportation cost, washed coal Table 15e
586	841	574	1992 mining cost/tonne Table BP 38-6-16813
615	720	555	1992 revenue/tonne Table BP 38-6-16813
173	236	175	1992 labor cost/tonne Table BP 38-6-16813
775	773	592	1994 Projected Mining Costs Table c.15
668	495	580	1994 Projected Revenue Table c.15

Table 7
SUMMARY OF
SELECTED MINE DATA

Mine	Recoverable Reserve *1			Current Reserve *2			Probable Market *3		Ind. Rcs. Com.	DHC's
	Tonnes (10^6)	Production (000)	Years	Tonnes (10^6)	Production (000)	Years	Novaky 94-98	Novaky 1998-?		
Zahorie *4	27	400	67	6	400	15	0	0	90	60
Novaky	35	1,600	22	20	1,200	17	1,100	900	0	0
Handlova	25	1,300	19	12	900	13	350	0	420	70
Cigel	28	1,850	15	15	900	17	470	200	300	0
Dolina	32	1,000	32	26	650	40	550	400	60	

*1 Requires unquantified additional capital investments
*2 Requires no significant additional capital investments
*3 Under assumptions of this report
- Novaky C retired
- Dis. heating using dom. brown coal continues to do so
- Res./comm. using dom. brown coal continue to do so
- 50% of industrials using dom. brown coal continue to do so
- Novaky A/B continue dom. brown coal use

*4 Does not consider new markets found for this mine

Attachment E

NATURAL GAS SECTOR WORKING PAPER

1.0 ASSESS CURRENT GAS SITUATION

1.1 Overview.

Natural gas use in Slovakia currently ranges from 5.5 to 5.7 billion cubic meters per year. Slovakia imports about 96% of its current natural gas requirements from the Commonwealth of Independent States (CIS), the remaining being local production. The imported gas enters Slovakia at the Ukraine border. Approximately 73 percent of the Slovak gas requirement is transported by the Brotherhood Pipeline (IGP-1) traversing the country from east to west terminating at the Czech border. The remaining amount is supplied by the transit gas pipeline, the West European supply system, which roughly parallels IGP-1.

IGP-1 is operated by Slovensky Plynarensky Priemysel (SPP). Connecting laterals and distribution lines serving outlying population centers, as well as the supply/withdrawal lateral serving the underground gas storage at Lab, are also operated by SPP. The underground reservoirs are owned and operated by Nafta Gbely, a private company. SPP receives gas on a substantially level rate during the year from its CIS suppliers; therefore, due to high seasonal variability in the use of gas, the underground gas storage is essential to the efficient operation of IGP-1 and to the maintenance of gas supply during peak demand periods.

Gas demand could grow significantly over the next ten years. The major driving force could be electric power generation as shown in the table below.

Current and Recent Projected Share of Gas Demand

Residential/Commercial	18%	19%
Industrial	79%	59%
Electric Power	3%	22%
	100%	100%

The impact of electric power requirements on coal demand will depend on the resulting demand for electricity. A lower growth will reduce the demand for coal.

The changing gas supply - demand situation has important implication for gas storage. Currently peak demand is 130% of average daily demand. Current gas storage peak day sendout is approximately 24 Million m^3 which is adequate to meet demand. Planned storage addition should add another 21 Million m^3 over the next ten years which should be adequate to meet projected peak demand.

The growth in gas market will of necessity involve changes in market participants - including private investors, independent power producers and cogenerators. Responding to these changes the suppliers of natural gas must also evolve to a structure which is capable of supplying gas efficiently and competitively. In anticipation of such changes SPP has already developed a plan to restructure itself into a holding company which would allow divestiture of certain segments of its business as the market and private investors dictate. As these changes occur the role of regulation must be evaluated to insure the industry operates within a competitive framework.

1.2 Supplies.

96% of the natural gas demand is supplied from imported the CIS. The remaining 4% from local production is produced in Eastern Slovakia, near the underground gas storage reservoirs.

The approximate breakdown of the supply for 1991 is as follows:

	millions m^3/year
IGP-1	3,930
Transit Gas Pipeline	1,950
Total from CIS	5,880
Internal production	200
Total supplies	6,080

1.3 Transmission and Distribution.

The main transmission line, IGP-1, starts at the Ukraine border and extends westerly approximately 422 km to a point near the town of Jablonica. From there the pipeline branches, one branch going south 53 kilometers to the Lab Underground gas storage area, north of Bratislava. The other branch continues northwesterly for 35 km to the Mokry Haj Meter Station and connection with CPP. The pipeline is 700 mm (28 inches) in diameter, with an operating pressure of 55 bars. There are three compressor stations with electric drives.

SPP also operates an extensive network of secondary pipelines branching off from IGP-1 and serving population centers north and south of IGP-1. These secondary lines range in size from 700 mm down to 150 mm, with a total overall length of 4,681 kilometers.

The distribution system, also operated by SPP, serves over 900,000 customers and includes 8,682 kilometers of local networks and house service pipes.

1.4 Gas Demand.

Gas demand in 1992 was 5.7 bcm excluding losses and SPP uses. This represented and decrease of 0.3 bcm from 1991. A breakdown of the demand for 1990, 1991 and 1992 is shown on Table 1.1

Table 1.1 History of Natural Gas Consumption (Mcm).

Category	1990	1991	1992
Industrial wholesale, direct	3,261	3,098	2,914
Industrial wholesale, networks	1,243	1,282	1,244
Inhabitants, (residential)	847	916	856
Chemical processing	803	506	408
Retail or small commercial	228	244	225
Losses	52	57	97
Internal uses	3	2	3
Total	6,437	6,084	5,746

Source: SPP

1.5 Future Gas Use.

SPP forecasts the consumption os natural gas to increase from 5.7 billion cubic meters in 1992 to 9.7 BCM in 2005. Over 80% of this increase results from forecasted increases in gas used for electric power generation and an increase in use by inhabitants (residential).

The increase for electric power results primarily from substitution of natural gas fired steam plants for nuclear energy in addition to construction of new gas steam and heat plants.

Regarding residential use, the increase is due primarily to conversion of existing residents from solid and liquid fuels to gas and to a large percentage of new construction being gas.

Table 1.2 following gives the SPP forecast for the various sectors of consumption:

Table 1.2 Forecast of Gas Consumption by Category of Users (Mcm).

Category	1992	1995	2000	2005
Total forecasted use	5,928	6,265	9,100	10,000
Losses and internal uses	272	240	340	385
Total net consumption	5,656	6,025	8,760	9,615
Industrial sector	4,576	4,825	7.245	7,720
Prime industries	3,211	3,335	3,725	4,000
Agricultural and forestry	502	510	520	530
Construction industry	222	230	250	290
Transportation	33	50	100	100
Power, Electric and heat	200	200	2,100	2,200
Chemical processing	408	500	550	550
Inhabitants (residential)	856	930	1,190	1,500
Commercial and tertiary	224	270	325	395

Source: SPP

For comparison, the forecast in the Energy Concept Report for the year 2005 is 9,200 million cubic meters. The difference is in the forecast of use by the electric power industry, SPP having forecast a more rapid substitution of natural gas for nuclear energy. Other categories of demand are substantially the same for the two forecasts.

1.6 Commercial Arrangements.

During the past 20 years the gas system in the CFSR has been planned and operated as a unified gas system. Gas destined for CPP is received at the Ukraine border and transported across Slovakia into the Czech Republic without measurement at the Slovak-Czech border, making an exact separation of the costs of gas between Czech Republic and Slovakia impossible. Slovakia also receives natural gas from the CIS in lieu of transit fees for the Transit Gas Pipeline, further adding to the complexity of deriving the real cost of gas at the Ukraine border. However, relying on the SPP 1992 annual report, the average gas cost can be calculated at 2.15 S/cubic meter.

Regarding the costs for underground gas storage, Nafta Gbely sells natural gas storage on a volume basis, without a further charge for injection or withdrawal. In 1992, SPP had approximately 1.2 billion cubic meters in storage at a unit price of 0.24 Sk/cubic meter, for a total cost of 288,000,000 Sk.

The selling price of gas to industrial consumers is negotiated between SPP and the buyer while to small consumers, the maximum price is set by the Ministry of Finance. The following schedule of prices has recently been in effect:

Category	Price - Sk/m^3
Industrial and power	3.21
Chemical Process	2.96
Commercial	3.14 + 88 Sk/month
Residential (150-6000 m^3/yr)	1.73 + 88 Sk/month
Residential (up to 150 m^3/yr)	2.94

2.0 ADVISE ON ALTERNATE GAS SUPPLIES STRATEGIES

2.1 Future Supply, Sources, Prices.

As shown in Table 2.1, SPP forecasts a gas demand of 10 billion cubic meters by 2005, or the alternative forecast of 10.5 billion cubic meters by 2010. The questions then arises as to how this demand will be met.

2.1.1 Supply Scenario: SPP is reviewing several diversification strategies involving the importation of natural gas in the form of LNG (from Algeria, Libya, Norway or Venezuela), or natural gas by pipeline from either the North Sea or Iran. In each strategy, SPP is a member of a consortia composed of several other European gas companies.

Fluor Daniel (a US engineering company) has conducted a study to determine the feasibility of replacing the existing IGP-1 with a new pipeline, IGP-2. IGP-1, commissioned in 1969, is being downgraded through reduced operating pressures and was scheduled be removed from service in 2002. Fluor Daniel has recommended replacing IGP-1 in two phases with a new 1400 mm pipeline. It is noted, however, that after the Fluor Daniel recommendation, a "smart pig" test of IGP-1 has been conducted. The results of the test indicate that the condition of the pipeline may warrant a longer life than anticipated at the time of the Fluor Daniel feasibility study and may not require complete replacement by 2002. However, for the purpose of this analysis, the conservative Fluor Daniel schedule of pipe replacement will be retained.

In addition to these diversification strategies mentioned above, SPP can also expand its take from the CIS, either through expansion of its IGP-2 or from the Transit gas pipeline system. Although the large underground gas storage fields available in Slovakia will tend

to diminish the risk of a single source, it seems at this time Slovakia will follow a diversification strategy and have two or more suppliers.

The following is one scenario in which diversification projects are phased in by 2005:

Table 2.1 Natural Gas Supply Scenario to 2010 (Mcm).

	1992	1995	2000	2005	2010
IGP-1	4,000	4,200	2,000	--	--
IGP-2	--	--	4,900	7,000	7,000
Transit Gas Pipeline	1,500	1,700	1,600	1,200	1,500
Internal production	200	400	600	500	500
Diversification	--	--	--	1,300	1,500
Total	5,700	6,300	9,100	10,000	10,500

2.1.2 Diversification Projects:

LNG

SPP is currently considering the importation of LNG from at least three sources: Algeria, Libya, and Venezuela. The LNG will be supplied either through a new regasification terminal on the Adriatic, or through existing terminals on the North Sea. If the terminal on the North Sea is selected, Slovakia would receive gas through an exchange arrangement with one of the European gas distributors, thereby reducing pipeline transportation costs to Slovakia. If the LNG is received through the new terminal on the Adriatic, the re-gasified LNG will be pipelined through either Slovenia or Croatia, through Austria, and into Slovakia.

Algeria is by far the most active natural gas exporter to Europe and seems the most likely of the three for the source of LNG. It is already linked to Western Europe through Trans-Med Pipeline, which traverses Tunisia, crosses the Mediterranean underwater, crosses Sicily and into Italy. In addition, it exports LNG to several Western European buyers. Some 30 billion cubic meters per year are currently committed to Europe, growing to 46 billion by 2000. Recoverable natural gas reserves are reported to be 3.3 trillion cubic meters (3.3×10^{12} cubic meters). Based on annual exports of 46 bcm, this results in a reserve/production ratio of approximately 70 years.

Venezuela is constructing its first LNG processing plant. The natural gas reserves in Venezuela are substantial and are adequate to support this export

project; however, the tanker distance is greater than from Algeria and would probably require a larger tanker fleet for the equivalent amount of LNG.

Libya, being closer to the Adriatic than Algeria, is very strategically located to supply the LNG. Libya currently exports LNG to Spain and Italy. The adequacy of the natural gas reserves in Libya to take on the addition export project is not known. Political risk involved may make the financing of an LNG export project in Libya impossible.

NORTH SEA

SPP is considering projects importing gas from the North Sea from either the British or Norwegian sectors. One proposed project, Polpipe, will transport gas from the British Sector,through either Northern Germany or Denmark, through Poland and into Slovakia. The pre-feasibility study has been completed. The consortia consists of British Gas, Texaco, ELF, DONG (Danish), POGC (Poland), Sante Fe Exploration (UK), and SPP. Norway may also participate.

There are other pipeline projects planned to bring North Sea gas into Western Europe: Zeepipe from Troll/Sleipner fields into Belgium and Europipe which will tie into the European network at Emden, Germany. In order to supply Slovakia, the existing pipeline network in Germany would have to be expanded through the Midal or Stegal systems.

The Government of the United Kingdom has until recently banned the export of gas to Continental European buyers in order to preserve self-sufficiency. The policy is now in the process of being changed, but the question remains as to whether the UK natural gas reserves are adequate to sustain a long-range export project.

Norwegian reserves now total about 3 trillion cubic meters. Exploration and development is continuing and its highly probable that additional reserves will be established; however, the lead time required to bring new discoveries on stream ranges from 8 to 12 years. Norway now has a total export potential of 65-70 bcm based upon existing contracts and contract options.

IRAN

The Iranian gas may enter the Eastern or Central European market through either Turkey-Bulgaria or through Ukraine.

Iran has reserves of about 14 trillion cubic meters and currently produces 20 bcm per year, mostly for local use. Iran is developing the North Pars field

which could come on stream in 1995. The long distance involved in transport to Europe requires a large natural gas volume, in the range of 20 bcm per year, in order for the pipeline to be competitive with other natural gas sources. It is not clear whether Iran can find buyers for this large quantity of gas.

2.1.3 Natural Gas Prices: Arthur D. Little Company, (ADL), a world energy consultant, has computed the costs of bringing natural gas from various sources to Slovakia. They are technical costs associated with the facilities required to produce and transport the gas to Slovakia. In each case it assumed that there are other buyers than Slovakia so that economies of scale can be realized. The calculations include a number of simplifying assumptions and ADL has assessed the degree of accuracy of the estimates at approximately 30 percent.

ADL also notes that the costs calculated are not gas prices. Gas prices are determined by negotiation between buyer and seller and may or may not reflect the costs. The purpose of the exercise was to rank the individual supply options and indicate implications for border prices that may be required to bring the new deliveries on stream. Table 2.2 gives the costs of 9 sources ranked in order of delivered cost. It is noted that the CIS options are the least costly while the Norwegian gas is the most costly.

Table 2.2 Supply Costs of Gas Delivered to Slovakian Border

Source	Field/route	Point of Delivery	Delivered cost-$/Mcm	Available From	Bcm per yr.
CIS	Karachaganak	Uzgorod	50	1996	35
CIS	Turkmenistan	Uzgorod	63	1998	35
Iran	South Pars	Uzgorod	69	2000	20
CIS	West Siberia	Uzgorod	90	2000	35
Algeria	Existing LNG	Bratislava	99	1995	5.5
Algeria	New LNG	Bratislava	105	1996	5.5
CIS	Barents Sea	Uzgorod	129	2000	35
Norway	Via Emden	Bratislava	131	1998	5
Norway	Via Poland	Bratislava	133	2000	5

Source: ADL

These costs tend to verify the prices stated in the Energy Concept Report of US$40 for CIS gas and US$140 for gas from the Northern, Southern or Western Routes.

2.2 Role of the Underground Storage Field.

The underground gas storage field, near Lab, is owned and operated by Nafta Gbely, a private company. The storage complex has an active storage capacity of 1.650 bcm and a maximum injection/withdrawal rate of 24.8 mcm per day.

Approximately 2/3 of the capacity is utilized by SPP,1/3 by CPP and a small amount by others.

2.2.1 Description of Current Operation. The Lab underground gas storage complex consists of one main center plus 5 outlying collection points. A schematic layout of the complex is shown in Figure 2.1.

The main center contains compression and measuring equipment through which flows all gas for injection or withdrawal. Six gas turbine driven centrifugal compressors are located at the main center, each with 4,500 KW capacity. The compressors are used for summertime injection, compressing incoming gas from about 45 bars to a maximum of roughly 90 bars. The compressed gas is then carried by 350 mm and 450 mm diameter pipelines to the collection centers, a distance of about 15 kilometers, where it is injected into the individual wells. The well lines are 100 mm diameter. There are an average of 25 injection wells at each injection center.

On the withdrawal cycle, the gas is dehydrated, heated and then transported to the main center, where it is measured before entering the main pipelines.

2.2.2 Future Expansion Plans. Construction is underway on an expansion program, designated Phase IV, to add an additional 780 billion cubic meters of active storage capacity and withdrawal/injection rates of 8.5 million cubic meters per day. Phase IV is a joint venture of SPP and Nafta, with SPP contributing the cushion gas, plus some amount of cash. The remaining project cost is being financed by a loan of ECU 42 million from EIB.

Phase IV includes the development of depleted gas production fields, shown as ZS-6 and ZS-7 in Figure 2.1, with the drilling of injection/withdrawal wells and the replacement of the cushion gas. Gas will be stored at a maximum pressure of 150 bars. Start-up is scheduled for 1996 with full capacity being reached in 2002.

There are other prospective reservoirs in the Lab-Gajary area of Western Slovakia that could be developed that would increase the capacity to 3,720 bcm to meet the storage demands of 2010.

2.2.3 Operation of Storage to Meet Demands. The underground gas storage operation has

been analyzed by EGU resulting an active storage requirement of 2,790 million cubic meters and a peak day delivery capacity of 22.4 to 25.4 million cubic meters by the year 2005 and 3180 and 29.0, respectively, by 2010. The derivation of these values is not fully explained in the text.

A further analyzed has been made by Bechtel, using a spreadsheet model that incorporates output from ELFIN for the natural gas requirement for power, electric and heat. Although the data used is only sample data, this model follows closely the results stated in the Energy Concept Report for maximum daily withdrawals, but indicates somewhat less required active storage capacity, showing a requirement of 1,690 million cubic meters by 2005.

An explanation of the assumptions and methodology used in the model follow:

- The total consumption for 1992 has been divided into the three categories: Industrial, Power and Residential/commercial. The total for each category has been provided by SPP.

- The 1992 distribution by month for each category has been computed pro-rata based upon monthly sendout data, provided by SPP, and the category annual totals.

- The monthly purchase data has been provided by SPP. An adjustment has been made in the data so that the total amount of purchases equals the total sendout.

- For the years after 1992, the Industrial and Residential/Commercial monthly sendouts have been factored based on the ratio of yearly forecast totals for each category to the 1992 total. The monthly sendout for power has been derived from the output of the ELFIN Generation Model, converting the output in energy to gas volume using the heat ratio of 33.71 MJ/m^3. The 1992 sendout for power has been added to the requirement derived from the ELFIN Generation Model data.

- For the summary data, the total active storage utilized is the sum of the monthly storage withdrawals.

- The factor of 130% for peak day demand has been derived in the Feasibility Study on Natural Gas Underground Storage Czech Republic and has been used for this analysis.

- The factor of 5% for other sources is an allowance for additional gas that might be made available during the peak day from line pack, additional indigenous production or from the Transit Gas System.

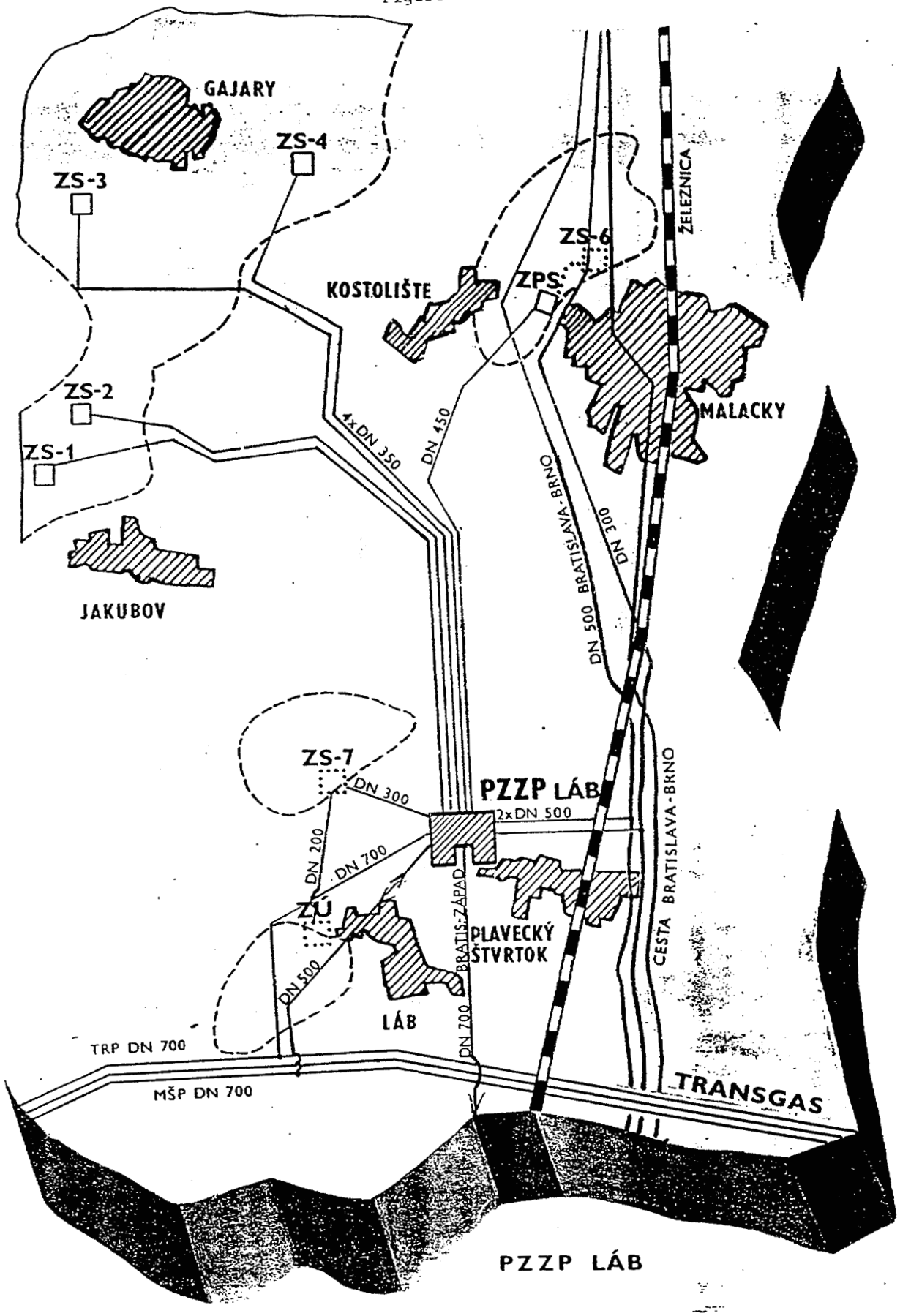
2.2.4 Costs and Benefits of Storage.

Nafta Gbely has engaged a consulting firm to compute storage costs at various levels of development of the underground storage operation. These costs, stated in the Energy Concept Paper, will not be restated here but decline to 1,105 Sk/m^3 of deliverability and 0.299 Sk/m^3 of active storage capacity. These costs appear reasonable and will not be reviewed here. The price charged SPP for storage space for 1993 is 0.45 Sk/m^3.

The economic benefits of storage can be derived by computing the costs of the facilities required to supply the same delivery capacity as the underground gas storage facility. At a minimum, this would require the construction of a pipeline from the Ukraine border with a carrying capacity of 16 million cubic meters per day, plus an additional amount required to replace the Czech peak shaving requirement that is met by the Lab storage complex. In addition, the Russians would have to expand their capability to deliver the added quantity of gas, probably increasing the unit cost due to the relatively low load factor operation.

The economic benefits can also be computed by the estimating the costs of providing other fuels, such as propane, to replace the peak shaving natural gas. This cost should include the environmental costs associated with the use of propane or other fuel as well as the conversion costs of the users' facilities.

Figure 2.1



NAFTÁR – odborný časopis, vydává Nafta, a. s. Gbely. Registrácia: Okr. úrad Senica, reg. č. 6/91. Vytlačila Grafia Kyjov.

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3.0 IMPLICATIONS FOR GOVERNMENT POLICY

3.1 Current Policy.

The Government through the Ministry of Finance regulates the gas industry in Slovakia, by the same branch that regulates electricity, transportation and water. As on now, the Ministry of Finance has set two levels of prices for natural gas, the higher price for industrial and a lower price for residential consumers, in effect, subsidizing the residential consumers. In regulating prices for residential consumers, the Ministry of Finance sets a ceiling price which SDD must follow. For industrial prices, the Ministry of Finance provides guidelines regarding what is economically reasonable.

The Ministry of Finance has an announced intention of adjusting prices in 1994 to reflect costs. The prices will include the border price plus the distribution costs. The distribution costs will reflect "reasonable profits" plus costs plus an allowance for depreciation. It is up the Ministry of Finance to define what "reasonable profits" are. It is not clear as to how this will be done.

Prices now are set uniformly throughout Slovakia, without adjustments for differences in distribution costs. In the 1994 adjustment, the Ministry of Finance intends to recognize regional differences in industrial prices but not in residential.

3.2 Identify Gas Policy Objectives

The Government's general principles in regard to the natural gas industry should include these following objectives:

- Secure a stable long-term supply sufficient to meet expected gas demand increases.
- Maximize the security of supply in terms of political and technical reliability.
- Minimize the foreign exchange costs of supply.
- Establish a conservation policy by initiating a pricing mechanism that ultimately leads to market based prices.

While these are policies that can be taken at the national level, they must be enacted through SPP. The decisions that SPP makes in regard to alterative supplies is crucial to the enactment of these policies. Each of the alternatives diversifies supply, and diversification reduces technical and commercial risk by improving negotiating positions with suppliers. However, the benefits of diversification must weighed against the increased costs of gas that might be required to diversify, as well as the impact that each might have on

foreign exchange.

3.3 Areas requiring government action.

The government must be involved in the rate setting mechanism in order to ensure that natural gas is supplied to the consumer at the lowest possible price consistent with maintaining a viable industry.

The government must further define the role of SDD in the Slovakian gas industry; should it be a private company whose objective is to maximize profit, or should it function as a regulated utility supplying consumers at the lowest possible costs.

The government must participate in the decision regarding future gas supplies. This decision will have great impact on the Slovakian economy, effecting balance of trade, future energy costs as well as security of supply.

The government must be involved in decisions regarding capital expenditures and expansions in the gas industry to ensure that these decisions are prudent and in the best interests of the Slovak economy and gas consumer.

The government must promote conservation measures within the gas industry. This can be accomplished through the rate setting mechanism and through initiatives to upgrade the natural gas transmission and distribution facilities, thereby reducing losses and unaccounted for gas.

3.4 Recommendations for policy initiatives.

The Ministry of Finance is currently pursuing a policy of adjusting natural gas prices to more closely follow market prices. We recommend that this policy be continued. A price formation mechanism should be adopted that will lead to prices high enough to encourage conservation.

Due to the complex issues involved in setting fair prices in a monopolistic situation, we recommend that Energy Regulation Agency be established to handle pricing and other regulatory issues.

Transportation and storage costs should be minimized through economies of scale, which are likely to be available through increased transportation service resulting from the replacement of IGP-1 with IGP-2, and increased utilization of the underground gas storage facilities. The costs may be further minimized by optimizing design and facilities sizing through use of computer simulation models.

Continue the policy of diversification of supply by securing amounts of gas from more than one supplier; however, the benefits of diversification should be weighed against the additional costs of some sources (e.g., Norwegian) as compared to CIS sources. The suppliers should supply extensive backup supply arrangements.

4.0 COMMENTS ON ENERGY CONCEPT REPORT

The Energy Concept Report contains a very thorough summary of recommendation that covers virtually all aspects of energy policy. The following are comments on areas that, although may be mentioned in the Report, are in my opinion not covered in sufficient emphasis.

- The Energy Concept Report primarily focuses on the electric power industry with less emphasis on the primary energy resources. Natural gas use will expand from supplying 25% of the basic energy needs to 35% in 2010. Since 96% of the natural gas requirement is imported, the decisions made now in regard to future supplies of natural gas will have an impact on the Slovak security of supply as well as future foreign exchange requirements. Diversification increases security of supply and can obviously be obtained at a price, but this has to be weighed against less costly, less secure alternatives. This issue has not been addressed in sufficient detail in the Concept Report and only in very general terms in the Recommendations. I believe that this issue should have more thorough coverage in the Report.

- The Report should make a statement regarding whether or not a new regulatory body should be established to set prices of natural gas. As of now, the Ministry of Finance has this responsibility. Should this policy be continued or should a new body be established?

- The method of computing natural gas underground storage requirements and costs has not been explained in sufficient detail. The same comment applies to many other cost estimates relating to the natural gas sector.

- The setting of natural gas prices is another area should be covered more thoroughly in the Report. Now, residential prices of natural gas are set under market prices. A very firm statement should be made regarding what policy should be followed in future setting of natural gas prices to the residential consumer.

Attachment F

Description and use of the ELFIN Model in the case study

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F.1 POWER SYSTEM DISPATCH SIMULATION PROGRAM (ELFIN)

In order to demonstrate the use of power system dispatch simulation software and to perform the development and economic evaluation of alternative expansion variants, we have conducted a case study with four expansion variants. For each of the expansion variants detailed power system dispatch simulation was performed. The simulations were performed using the ELFIN model developed by the Environmental Defense Fund and licensed to the Ministry of Economy in Slovakia. The ELFIN output was then imported to the spreadsheet based economic model. In the economic model capital costs, fixed O&M costs as well as costs and benefits of heat production were summarized with the operating costs provided by ELFIN, resulting in total cost for expansion variant.

ELFIN is a computer simulation model for the analysis of electric utility systems. ELFIN uses a probablistic, load-duration curve method to simulate the production of electrical energy to meet loads. The model produces reliability results, production costs, marginal cost, and other data.

The major input supplied to the model was the overall level and pattern of electrical energy demands, and the operating cost and performance characteristics of generating units. The model determines the least-cost manner of operating the generating units within the given time period, in such a manner as to maximize overall system reliability.

For this analysis, the ELFIN model was supplied with electrical energy demands and performance characteristics of generating units in the Slovakian power system up to the year 2005. This was assumed to be the planning horizon adequate to verify the overall performance of the expansion variants.

F.2 System Reliability

Each alternative variant investigated is required to meet similar system reliability criterion so as to ensure a fair comparison. The most common system reliability measure for thermal systems such as that of NEC is loss-of-load probability (LOLP). LOLP is defined as the probability that the generating system will be unable to meet system demand during a given period of time. It can be expressed as a percentage, but more often in days per year.

Uncertainty in future demand, maintenance requirements, spinning reserve requirements, and the possibility of unexpected outages require that the generating capability of a power system exceed the peak load. This amount is called the reserve margin. Typical large interconnected power systems in the U.S. are planned so as to meet a LOLP criteria of .1-.2 days per year, requiring reserve margins in the 15-20% range. However, smaller systems with less reliable units such as those in Slovakia can meet such reliability criteria when reserve capacity is in the 25-30% range.

New stations were added to the system based on the criteria that LOLP should be lower or close to .1 days per year.

F.3 ANALYTICAL TECHNIQUE

Alternative selection is based on economic analysis with the objective of minimizing the projected present worth of cost of supplying electricity and heat. Assumption is that all variants serve the same electric load resulting in same electrical revenues. For heat production net revenues are included since heat loads served by new GCC's are different among variants. Linear depreciation of investments over the plant life is assumed when accounting for the end effects. The projected cost for a given strategy "i" is defined by the following formula:

Present Worth of all Costs and Heat Revenues for Strategy i =

$$\sum_{j} (C_{ij}+F_{ij}+O_{ij}-(HR_{ij}-HC_{ij}))/(1+d)^{(j-1)}$$

where

j = year
d = discount rate
C_{ij} = the capital-related costs of Strategy i in year j
F_{ij} = the system fuel cost associated with Strategy i in year j
O_{ij} = the variable non-fuel operating and maintenance (O&M) cost for the system plus the incremental fixed O&M costs associated with Strategy i in year j

HC_{ij} = the costs for heat production for Strategy i in year j
HR_{ij} = heat revenues associated with Strategy i in year j

Fuel costs and variable O&M cost are estimated based on the results of the system simulation using the ELFIN model. Fixed O&M costs are based on SEP estimates for the various units on the system.

Attachment G

Case Study Input and Output Data

Table of Contents

ELFIN Input Data File	G-1
Output Tables	G-36

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```
#       ****************************************************************
#       **                                                            **
#       **                ELFIN Input Data File                       **
#       **                Slovakia Power System                       **
#       **                                                            **
#       **                                                            **
#       **        Variant 1 - is the SEP reference variant            **
#       **                  - rehab. of Vojany 1 units 3-6            **
#       **                                                            **
#       **        Variant 2 - do not rehab. Vojany 1 units 3-6        **
#       **                    add GCC to meet load                    **
#       **                                                            **
#       **        Variant 3 - best of 1 & 2 + retire Vojany 2         **
#       **                    units 5-6, add GCC's to meet load       **
#       **                                                            **
#       **        Variant 4 - use additional imports (long            **
#       **                    term contracts) rather than             **
#       **                    one GCC's.                              **
#       **                                                            **
#       **                                5.nov.1993/EGU              **
#       **                                                            **
#       ****************************************************************
#
#
#     *Create Input Data file:
#
#         **Define the generation parameters:
#
#           ***Define the base year.
#
baseyr 1 base year
        2  1992

lastyr 1 last year
        2  2010

fyear  1 12 typical weeks
        7  0.0849  0.0769  0.0849  0.0822  0.0849  0.0822
           0.0849  0.0849  0.0822  0.0849  0.0822  0.0849

elegen 1   list of power sources
        7   'ebo1'  'ebo2'
            'emo1'  'emo2'
            'ev12'  'ev34'  'ev56'
            'ev24'  'ev26'
            'enoa'  'enaa'  'enb1'  'enb2'
            'vahc'  'hydr'  'gabc'
            'senn'  'kosc'  'ziln'  'mart'
            'ziar'  'prsv'  'vojn'  'gast'
            'dist'  'brat'  'komr'  'indy'
            'dsmr'  'intr'
            'imp1'  'imp2'  'expt'
```

```
#
#           ** full names of power sources **
#
ebo1xx 0 Bohunice V-1
ebo2xx 0 Bohunice V-2
emo1xx 0 Mohovce 1
emo2xx 0 Mohovce 2
ev12xx 0 Vojany 1 b.1,2
ev34xx 0 Vojany 1 b.3,4
ev56xx 0 Vojany 1 b.5,6
ev24xx 0 Vojany 2 b.21-24
ev26xx 0 Vojany 2,b.25-26
enoaxx 0 Novaky A- 22 MW
enaaxx 0 Novaky A- 32 MW
enb1xx 0 Novaky B-100 MW
enb2xx 0 Novaky B- 79 MW
vahcxx 0 Vah Cascade
gabcxx 0 Gabcikovo
hydrxx 0 Other hydro
indyxx 0 Ind.-owned
distxx 0 Dis.-owned
bratxx 0 Bratislava GCC
komrxx 0 Komarno CHP
sennxx 0 Senne GCC
koscxx 0 Kosice GCC
zilnxx 0 Zilina GCC
martxx 0 Martin GCC
ziarxx 0 Ziar GCC
prsvxx 0 Presov GCC
vojnxx 0 Vojany GCC
gastxx 0 Simple Cycle
dsmrxx 0 Demand Side M'ment
intrxx 0 Interruptible Load
imp1xx 0 Imports
imp2xx 0 Emergency Imports
exptxx 0 Exports
ps 1xx 0 Pumped Storage
#
#
#           **Define the Generation Summary Categories (used for the
#                generation reports)
#
gensum 1 Nuclear
        7  'ebo1'  'ebo2'  'emo1'  'emo2'
gensum 2 Lignite
        7  'enoa'  'enaa'  'enb1'  'enb2'
gensum 3 Coal
        7  'ev12' 'ev34'  'ev56'
gensum 4 Gas
        7  'vojn' 'gast' 'ziar'  'ev24'  'ev26'
gensum 5 Gas - Combined Heat and Power
        7  'senn' 'kosc' 'ziln'  'mart'  'prsv'
```


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```
gensum 6 Hydro
        7  'vahc' 'gabc'  'hydr'
gensum 7 Demand-side mngmnt.
        7  'dsmr'
gensum 8 Emergency Imports
        7  'intr'
gensum 9 Import/Export
        7  'imp1'  'imp2'  'expt'
gensum10 Industrial Plants
        7  'indy'
gensum11 District Heating Plants
        7  'dist'  'brat'  'komr'

sales 1 monthly energies from the spreadsheet SEP_LOAD.wk1

        20  0.0964  0.0857  0.0909  0.0820  0.0774  0.0742
            0.0719  0.0765  0.0772  0.0850  0.0884  0.0944
# Yearly Energy (GWh)
         y1992  21759
         y1993  20552
         y1994  19865
         y1995  19858
         y1996  20227
         y1997  20730
         y1998  21477
         y1999  22249
         y2000  23049
         y2001  23884
         y2002  24748
         y2003  25684
         y2004  26568
         y2005  27534

peak  1 relative monthly peaks
        25  0.996  0.976  0.947  0.898  0.824  0.808
            0.769  0.818  0.871  0.908  0.972  1.000
# Peak Load
         y1992  3458
         y1993  3390
         y1994  3162
         y1995  3184
         y1996  3264
         y1997  3367
         y1998  3493
         y1999  3630
         y2000  3770
         y2001  3916
         y2002  4069
         y2003  4228
         y2004  4385
         y2005  4550
```

```
losses 1 transmission and distribution losses
#  from the spreadsheet SEP_LOAD.wk1
        17 y1992  0.095
           y1993  0.087
           y1994  0.085
           y1995  0.087
           y1996  0.087
           y1997  0.088
           y1998  0.086
           y1999  0.085
           y2000  0.085
           y2001  0.084
           y2002  0.084
           y2003  0.084
           y2004  0.084
           y2005  0.084

#
#            ***Define the subperiods.
#              1 = weekdays, 2 = weeknights, 3 = weekends
#
subprd 1
        19  y1992  mon 12am 3   6am 1  10pm 2
                    tue 12am 2   6am 1  10pm 2
                    fri 12am 2   6am 1  10pm 3
                    sat 12am 3
wkend  1 subperiod 3 is weekend
        7   3
#
#            ***Define seasons for seasonal summary report
#
seasum 1    Winter
        7    12   1   2
seasum 2    Spring
        7     3   4   5
seasum 3    Summer
        7     6   7   8
seasum 4    Autumn
        7     9  10  11
#
#
#          **Define the commitment requirements.
#
commit 1
#
# Commitment levels adjusted to asure that Vojany I is committed
# assuming full capacity availability from Gabcikovo and pumped storage.
# It is recognized that Gabcikovo capacity is not fully available, so
# that commitment levels are overstated. If Gabcikovo modeling is
# modified, these committment levels should be adjusted.
#
        24    y1993  1.23  1.23  1.27  1.33  1.33  1.33
```


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```
                1.33  1.33  1.30  1.27  1.23  1.23
        y1997   1.23  1.23  1.27  1.30  1.30  1.30
                1.30  1.30  1.33  1.27  1.23  1.23

spnfr  1 10% above peak load for all subperiods
        2    .10    # This covers largest unit.

mrordr 1 overall must-run order
        7        'ebo1' 'ebo2' 'emo1' 'emo2' 'enoa' 'indy' 'imp1'
                  'dist' 'kosc' 'ziln' 'mart' 'prsv' 'senn' 'brat'
mrlast 1 all nuclear and industy are must-run all year, CHP units in the
#       fall and winter
        27   y199201 'brat'
             y199202 'brat'
             y199203 'brat'
             y199204 'dist'
             y199205 'dist'
             y199206 'dist'
             y199207 'dist'
             y199208 'dist'
             y199209 'dist'
             y199210 'brat'
             y199211 'brat'
             y199212 'brat'
#
#            ***Set fuel costs  (Another option would be to use each
#                                plant name instead of the fuel classes.)


# Fuel prices are from SEP and projection is from EGU - Brno
#
# Fuel costs expressed in Sk per GJ. Heat rates in kJ/kWh. (Designation per
#  mbtu is program convention.
# End of 1992 exchange rate of 28.6 Sk/US$ was used where conversion was
# necessary.
ngasfc 1 natural gas projected cost
        /mbtu 1   86.4
                  y1993  .075
                  y1996  .019
                  y1997  .019
lignfc 1 lignite projected cost
        /mbtu 1   55.8
                  y1993  .084
                  y1996  .071
                  y1997  .028
coalfc 1 coal projected cost
        /mbtu 1   39.2
                  y1993  .166
                  y1996  .029
                  y1997  .003
nuclfc 1 nuclear fuel projected cost
        /mbtu 1    9.5
```

```
                    y1993  .052
                    y1996  .020
                    y1997  .020
resdfc 1 residual fuel oil projected cost
        /mbtu 1   63.8
                    y1993  .026
                    y1996  .021
                    y1997  .021
#
# Import/Export costs  (expressed in Sk/kwh)
#
imptfc 1 import power cost 3.5 c/kWh
        /kwh  1   1.04   y1993   .005
imptfc 2 import power cost 5   c/kWh
        /kwh  1   1.48   y1993   .005
impefc 1 emergency import power cost
        /kwh  1   2.00   y1993   .005
exptfc 1 export power cost
        /kwh  1   1.04   y1993   .005

cstens 1 cost of energy-not-served
# Note: SEP April expansion plan was based on 50 Sk/kWh. FD and MB (Bechtel)
# thought this was high. This should be reviewed.
        2     5.

cstdmp 1 cost of dump energy
# based on the ability to sell dump energy to replace lignite generation
# in interconnected systems assuming a heat rate of 11 GJ/MWh.
        1  .43  # Sk/kWh
                    y1993  .166
                    y1996  .029
                    y1997  .003

# O&M costs
omn1om 1 variable o&m for Vojany I
        1  0.038        y1993 .00
omn6om 1 variable o&m for Vojany II and new GCC
        1  0.009        y1993 .00
omn2om 1 variable o&m for Novaky A
        1  0.009        y1993 .00
omn3om 1 variable o&m nuclear for Bohunice 1
        1  0.007        y1993 .00
omn4om 1 variable o&m nuclear for Bohunice 2
        1  0.006        y1993 .00
omn5om 1 variable o&m nuclear for Mochovce and Novaky B
        1  0.004        y1993 .00
#
#
#
#          ** Enter the plant data
#
#   NUCLEAR PLANTS *************
```

```
#
#           *** Bohunice V-1
#

ebo1cw 1 weekend-constrained capacity (net MW)
        22  399  399  399  399  399  399
           399  399  399  399  399  399
ebo1mu 1 number of units - reference case from SEP
        27  y199201  2
           y200001  2
           y200010  1
           y200101  1
           y200107  0
           y200201  0
ebo1ha 1 average heat rate (kJ/kWh) from SEP
        2   12500
ebo1fc 1 uranium, cost estimates above in 'nuclfc'
        fc=nucl
ebo1fr 1 forced outage rate from SEP
        2  0.07
ebo1mr 1 pre-scheduled maintenance from SEP
c INPUT MAINTENANCE SCHEDULE BASED ON SEP DATES.
        24 y1993  .500   .661   .952  .500   .500   .050
                  .000   .000   .000  .000   .333   .419
           y1994  .000   .000   .000  .317   .500   .067
                  .000   .000   .000  .355   .500   .032
           y1995  .446   .500   .500  .500   .333   .000
                  .000   .000   .000  .000   .000   .000
           y1996  .371   .500   .500  .417   .000   .000
                  .210   .500   .500  .500   .967   .000
           y1997  .000   .107   .500  .500   .500   .500
                  .500   .500   .333  .000   .000   .000
           y1998  .000   .000   .000  .317   .500   .067
                  .000   .000   .000  .403   .483   .000
           y1999  .000   .000   .355  .500   .032   .000
                  .000   .000   .100  .500   .283   .000
           y2000  .250   .452   .500  .032   .000   .242
                  .000   .000   .000  .000   .000   .000
           y2001  .000   .357   .226  .167   .000   .000
                  .000   .000   .000  .000   .000   .000

ebo1om 1 O&M
        om=omn3
#
#           *** Bohunice V-2
#
ebo2cw 1 weekend-constrained capacity (net MW)
        2   404.0
ebo2mu 1 number of units
        27  y199201  2
ebo2ha 1 average heat rate (kJ/kWh)
        2   12400
```


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```
ebo2fc 1 uranium, cost estimates above in 'nuclfc'
        fc=nucl
ebo2fr 1 forced outage rate
        2  0.07
ebo2mr 1 pre-scheduled maintenance
c INPUT MAINTENANCE SCHEDULE BASED ON SEP DATES.
        24 y1993  .000   .000   .000  .000   .000   .483
                  .500   .194   .450  .403   .000   .000
           y1994  .000   .000   .000  .000   .000   .317
                  .500   .339   .500  .048   .000   .000
           y1995  .000   .000   .000  .000   .000   .000
                  .403   .548   .500  .500   .267   .000
           y1996  .000   .000   .000  .083   .500   .500
                  .629   .500   .000  .000   .000   .000
           y1997  .000   .000   .000  .000   .000   .000
                  .145   .500   .367  .500   .183   .000
           y1998  .000   .000   .000  .000   .000   .317
                  .500   .339   .500  .048   .000   .000
           y1999  .000   .000   .000  .000   .435   .417
                  .435   .500   .433  .000   .000   .000
           y2000  .000   .000   .000  .317   .500   .500
                  .065   .161   .500  .194   .000   .000
           y2001  .000   .000   .000  .317   .500   .033
                  .242   .500   .100  .000   .000   .000
           y2002  .000   .000   .000  .450   .403   .000
                  .435   .403   .000  .000   .000   .000
           y2003  .000   .000   .194  .500   .161   .000
                  .500   .500   .367  .000   .000   .000
           y2004  .000   .000   .306  .500   .500   .067
                  .274   .500   .067  .000   .000   .000
           y2005  .000   .000   .000  .450   .403   .000
                  .242   .500   .100  .000   .000   .000

ebo2om 1 O&M
        om=omn4
#
#
#           *** Mohovce 1
#
emo1cw 1 weekend-constrained capacity (net MW)
        2   406.0
emo1mu 1 number of units
        27  y199201  0
            y199601  1
            y199701  2
            y199801  2
emo1ha 1 average heat rate (kJ/kWh)
        2   12300
emo1fc 1 uranium, cost estimates above in 'nuclfc'
         fc=nucl
emo1fr 1 forced outage rate
        2  0.07
```

```
emo1mr 1 pre-scheduled maintenance
        24 y1993  .000  .000  .000  .000  .000  .000
                  .000  .000  .000  .000  .000  .000
           y1994  .000  .000  .000  .000  .000  .000
                  .000  .000  .000  .000  .000  .000
           y1995  .000  .000  .000  .000  .000  .000
                  .000  .000  .000  .000  .000  .000
           y1996  .000  .321  .355  .200  .452  .000
                  .000  .258  .200  .000  .000  .774
           y1997  .194  .143  .000  .183  .065  .000
                  .000  .000  .333  .500  .750  .274
           y1998  .000  .000  .000  .000  .000  .467
                  .500  .306  .083  .500  .500  .290
           y1999  .000  .000  .000  .000  .000  .467
                  .500  .403  .000  .032  .500  .323
           y2000  .000  .000  .000  .000  .000  .000
                  .290  .500  .050  .306  .500  .048
           y2001  .000  .000  .000  .000  .000  .467
                  .387  .000  .000  .065  .500  .452
           y2002  .000  .000  .000  .000  .097  .500
                  .258  .000  .000  .419  .500  .452
           y2003  .000  .000  .000  .000  .452  .500
                  .419  .000  .000  .032  .500  .323
           y2004  .000  .000  .000  .000  .000  .417
                  .435  .000  .000  .210  .500  .145
           y2005  .000  .000  .000  .000  .097  .500
                  .258  .000  .000  .113  .500  .242

emo1om 1 O&M
        om=omn5
#
#
#           *** Mohovce 2
#
emo2cw 1 weekend-constrained capacity (net MW)
        2   406.0
emo2mu 1 number of units
        27  y199201  0
            y200001  0
            y200010  1
            y200101  1
            y200107  2
            y200201  2
emo2ha 1 average heat rate (kJ/kWh)
        2   12300
emo2fc 1 uranium, cost estimates above in 'nuclfc'
        fc=nucl
emo2fr 1 forced outage rate
        2  0.07
emo2mr 1 pre-scheduled maintenance
        24 y1993  .000  .000  .000  .000  .000  .000
                  .000  .000  .000  .000  .000  .000
```

```
        y1994 .000  .000  .000  .000  .000  .000
              .000  .000  .000  .000  .000  .000
        y1995 .000  .000  .000  .000  .000  .000
              .000  .000  .000  .000  .000  .000
        y1996 .000  .000  .000  .000  .000  .000
              .000  .000  .000  .000  .000  .000
        y1997 .000  .000  .000  .000  .000  .000
              .000  .000  .000  .000  .000  .000
        y1998 .000  .000  .000  .000  .000  .000
              .000  .000  .000  .000  .000  .000
        y1999 .000  .000  .000  .000  .000  .000
              .000  .000  .000  .000  .000  .000
        y2000 .000  .000  .000  .000  .000  .000
              .000  .000  .000  .387  .100  .323
        y2001 .226  .000  .000  .000  .000  .000
              .000  .081  .100  .145  .000  .371
        y2002 .500  .500  .032  .000  .000  .000
              .097  .500  .500  .290  .000  .000
        y2003 .355  .500  .500  .050  .000  .000
              .081  .500  .500  .290  .000  .000
        y2004 .194  .500  .194  .000  .000  .000
              .000  .161  .500  .194  .000  .000
        y2005 .194  .500  .194  .000  .000  .000
              .000  .000  .500  .355  .000  .000

emo2om 1 O&M
        om=omn5
#
#
#   LIGNITE PLANTS *************
#
#
#           *** Novaky Unit A- 22.4 MW (gross) turbines
#
enoacw 1 net capacity - slow start unit
        sh=enoa  1  21.25      # capacity is  24 MW, but max month average is
                               # 17 MW. Annual energy is given 109 GWh for all
                               # years, when used.

                        0.000  0.000 0.000    # growth rates from 1993
           0.000 0.000  0.000  0.000 0.000    # is not given
           0.000 0.000  0.000  0.000 0.000
           0.000 0.000  0.000  0.000 0.000

enoash 1
        29  y199201 mon 12am     21.25
           y199202 mon 12am     17.5
           y199203 mon 12am     16.25
           y199204 mon 12am     13.75
           y199205 mon 12am     13.75
           y199206 mon 12am     12.5
           y199207 mon 12am     12.5
```

```
            y199208 mon 12am     12.5
            y199209 mon 12am     13.75
            y199210 mon 12am     16.25
            y199211 mon 12am     17.5
            y199212 mon 12am     20
enoaha 1 average heat rates for each capacity state
        27  y199201  15700
            y199501   8500
enoamu 1 number of units
        27  y199201  1
enoamr 1 annual requirement, model will schedule among months
        2    0.15
enoafr 1 forced outage rate
        2    0.10
enoafc 1 coal, cost estimates above in 'coalfc'
        fc=lign
enoaom 1 O&M
        om=omn2
#
#
#           *** Novaky Unit A- 32 MW (gross) turbines
#
enaacm 1 net capacity - slow start unit
        27  y199201  27
enaaha 1 average heat rates for each capacity state
        27  y199201  15700
enaamu 1 number of units
        27  y199201  2
            y199601  2
            y199404  1
            y200001  1
            y200003  0
enaamr 1 annual requirement, model will schedule among months
        2    0.15
enaafr 1 forced outage rate
        2    0.10
enaafc 1 coal, cost estimates above in 'coalfc'
        fc=lign
enaaom 1 O&M
        om=omn2
#
#           *** Novaky Unit B- 100 MW (gross) turbines
#
enb1cm 1 net capacity (three capacity states) - slow start unit
        27  y199201      70     100
enb1ha 1 average heat rates for each capacity state
        27  y199201     13500  13000
enb1mu 1 number of units
        27  y199201  2
enb1mr 1 annual requirement, model will schedule among months
        2    0.15
enb1fr 1 forced outage rate
```

```
        2    0.10
enb1fc 1 coal, cost estimates above in 'coalfc'
        fc=lign
enb1om 1 O&M
        om=omn6
#
#            *** Novaky Unit B- 79 MW (gross) turbines
#
enb2cm 1 net capacity (three capacity states) - slow start unit
        27  y199201       65     79
enb2ha 1 average heat rates for each capacity state
        27  y199201     13500  13000
enb2mu 1 number of units
        27  y199201  2
           y199901  0
enb2mr 1 annual requirement, model will schedule among months
        2    0.15
enb2fr 1 forced outage rate
        2    0.10
enb2fc 1 coal, cost estimates above in 'coalfc'
        fc=lign
enb2om 1 O&M
        om=omn6
#
#
#   COAL PLANTS *************
#
#            *** Vojany I    ,bl. 1,2
#
ev12cm 1 net capacity (three capacity states) - slow start unit
        27  y199201  85   95   100   110
ev12ha 1 average heat rates for each capacity state
        27  y199201  9976 10042 9885 9998
ev12mu 1 number of units
        27  y199201  2
ev12mr 1 annual requirement, model will schedule among months
        27  y199301  0.058
           y199601  0.163
           y199801  0.058
           y200001  0.163
           y200201  0.058
           y200401  0.163
           y200501  0.163
ev12fr 1 forced outage rate
        2    0.12
ev12fc 1 coal, cost estimates above in 'coalfc'
        fc=coal
ev12om 1 O&M
        om=omn1
#

#
```

```
#           *** Vojany I    ,bl. 3,4
#
ev34cm 1 net capacity (three capacity states) - slow start unit
# with rehabilitation    SEP
        27  y199201   90     95     100
            y200001   50     75     100
ev34ha 1 average heat rates for each capacity state
# new plant characteristics after 2000 with rehabilitation
        27  y199201  13000  12800  12700
            y200001  10500  10000  9700
ev34mu 2 number of units without rehabilitation
        27  y199201  2
            y199701  2
            y199709  1
            y199801  1
            y199806  0
            y199901  0
ev34mu 1 number of units
# with rehabilitation
        27  y199201  2
            y199701  2
            y199709  1
            y199801  1
            y199806  0
            y199901  0
            y200001  0
            y200003  1
            y200101  2
ev34mr 1 annual requirement, model will schedule among months
# with rehabilitation
        27  y199301  0.058
            y199501  0.163
            y199701  0.058
            y200401  0.163
            y200501  0.163
ev34fr 1 forced outage rate
# with rehabilitation
        27  y199201  .12
            y199701  .12
            y199709  .12
            y199801  .12
            y199806  .12
            y199901  .12
            y200001  .12
            y200003  .07
            y200101  .07
ev34fc 1 coal, cost estimates above in 'coalfc'
        fc=coal
ev34om 1 O&M
        om=omn1
#
#
```

```
#           *** Vojany I    ,bl. 5,6
#
ev56cm 2 net capacity (three capacity states) - slow start unit
        27  y199201   90     95     100
ev56ha 2 average heat rates for each capacity state
        27  y199201  12850  12750  12650
ev56cm 1 net capacity (three capacity states) - slow start unit
# with rehabilitation
        27  y199201   90     95     100
            y199601   50     75     100
ev56ha 1 average heat rates for each capacity state
# with rehabilitation
        27  y199201  12850  12750  12650
            y199601  10500  10000  9700
ev56mu 2 number of units without rehabilitation
        27  y199201  1       #   y199208  1
            y199401  0
ev56mu 1 number of units  with rehabilitation
# with rehabilitation
        27  y199201  1       #   y199208  1
            y199401  0
            y199404  0
            y199501  0
            y199601  0
            y199607  1
            y199610  2
            y199701  2
ev56mr 2 annual requirement, model will schedule among months
        2     0.10
ev56fr 2 forced outage rate
        2     0.12
ev56mr 1 annual requirement, model will schedule among months
# with rehabilitation
        27  y199201  .058
            y200001  .163
            y200201  .058
            y200501  .163
ev56fr 1 forced outage rate
# with rehabilitation
        27  y199201  .12
            y199404  .12
            y199601  .12
            y199607  .07
            y199610  .07
            y199701  .07
ev56fc 1 coal, cost estimates above in 'coalfc'
        fc=coal
ev56om 1 O&M
        om=omn1
#
#
#   OIL PLANTS CONVERTED TO GAS ( Scenario 2 is for oil) **************
```

```
#
#           *** Vojany II bl. 21,22,23,24,
#
ev24cm 1 net capacity (three capacity states) - slow start unit
        27  y199201  65     88
ev24cm 2 net capacity (three capacity states) - slow start unit
        27  y199201  50     75     100
ev24ha 1 average heat rates for each capacity state
        27  y199201  12000  11000
ev24ha 2 average heat rates for each capacity state
        27  y199201  13000  12000  11000
ev24mu 1 number of units
        27  y199201  4
ev24mu 2 number of units
        27  y199201  4
ev24mr 1 annual requirement, model will schedule among months
        2    0.15
ev24mr 2 annual requirement, model will schedule among months
        2    0.15
ev24fr 1 forced outage rate
        2    0.10
ev24fr 2 forced outage rate
        2    0.10
ev24fc 1
        fc=resd
ev24fc 2
        fc=ngas
ev24om 1 O&M
        om=omn6
ev24om 2 O&M
        om=omn6

#          GAS
#            *** Vojany II bl. 25,26
#
ev26cm 1 net capacity (three capacity states) - slow start unit
        27  y199201  65     88
ev26ha 1 average heat rates for each capacity state
        27  y199201  12000  11000
ev26mu 1 number of units
        27  y199201  2
ev26mu 3 number of units - retire for new GCC
        27  y199201  2
           y199901  0
ev26mr 1 annual requirement, model will schedule among months
        2     0.15
ev26fr 1 forced outage rate
        2    0.10
ev26fc 1
        fc=ngas
ev26om 1 O&M
        om=omn6
```

```
#
#   INDUSTRY-OWNED PLANTS **************
#
indycw 1
        sh=indy   1   368
                        -0.056 -0.035 0.003    # growth rates from
           0.019 0.031  0.030  0.030 0.030    # 1993 through 2010
           0.030 0.030  0.030  0.030 0.030
           0.030 0.030  0.030  0.030 0.030

indysh 1 zadavam tyzdenny priebeh pre jednotlive roky
        29  y199201 mon 12am    327  6am    357  10pm    347
                tue 12am    347  6am    357  10pm    347
                fri 12am    347  6am    357  10pm    327
                sat 12am    327
           y199202 mon 12am    319  6am    342  10pm    333
                tue 12am    333  6am    342  10pm    333
                fri 12am    333  6am    342  10pm    319
                sat 12am    319
           y199203 mon 12am    305  6am    333  10pm    323
                tue 12am    323  6am    333  10pm    323
                fri 12am    323  6am    333  10pm    305
                sat 12am    305
           y199204 mon 12am    259  6am    283  10pm    275
                tue 12am    275  6am    283  10pm    275
                fri 12am    275  6am    283  10pm    259
                sat 12am    259
           y199205 mon 12am    214  6am    231  10pm    224
                tue 12am    224  6am    231  10pm    224
                fri 12am    224  6am    231  10pm    214
                sat 12am    214
           y199206 mon 12am    211  6am    227  10pm    218
                tue 12am    218  6am    227  10pm    218
                fri 12am    218  6am    227  10pm    211
                sat 12am    211
           y199207 mon 12am    200  6am    212  10pm    208
                tue 12am    208  6am    212  10pm    208
                fri 12am    208  6am    212  10pm    200
                sat 12am    200
           y199208 mon 12am    202  6am    215  10pm    209
                tue 12am    209  6am    215  10pm    209
                fri 12am    209  6am    215  10pm    202
                sat 12am    202
           y199209 mon 12am    210  6am    221  10pm    213
                tue 12am    213  6am    221  10pm    213
                fri 12am    213  6am    221  10pm    210
                sat 12am    210
           y199210 mon 12am    264  6am    269  10pm    277
                tue 12am    277  6am    269  10pm    277
                fri 12am    277  6am    269  10pm    264
                sat 12am    264
           y199211 mon 12am    318  6am    336  10pm    326
```


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```
                tue 12am    326  6am    336  10pm    326
                fri 12am    326  6am    336  10pm    318
                sat 12am    318
        y199212 mon 12am    341  6am    368  10pm    358
                tue 12am    358  6am    368  10pm    358
                fri 12am    358  6am    368  10pm    341
                sat 12am    341

indyha 1 average heat rates for each capacity state
        27  y199201  10945          # GJ/kWh merna spotr., prepocitane na Btu
indynu 1 number of units
        27  y199201  50
indymr 1 annual requirement, model will schedule among months
        2    0.00
indyfr 1 forced outage rate
        2    0.00
indyfc 1
        fc=resd
indyom 1 O&M
        om=omn1
#
#   DISTRIBUTION-OWNED PLANTS **************
#
#   Tp Komarno
# This is a potential project. It is not considered for the Case Study
# demonstration based on the uncertainty of project future and the
# small electric capacity. (Agreed on in discussion between Bechtel and
# EGU on October 27, 1993).

komrcm 1 net capacity (three capacity states) - slow start unit
        27  y199201  5      6
komrha 1 average heat rates for each capacity state
        27  y199201  13000  12000
komrmu 1 number of units
        27  y199201  0
komrmr 1 annual requirement, model will schedule among months
        2     0.15
komrfr 1 forced outage rate
        2    0.10
komrfc 1
        fc=resd
komrom 1 O&M
        om=omn1

# Other Distibution Owned Plants

# This group of units is modeled assuming that units cannot operate if
# they are not delivering heat. Heat delivery is assumed to be 50% of the
# time for May and September and 100% of the time for Jan-Mar. and Oct.-
# Dec.
# Monthly capacity is based on heating requirements. Remaining capacity
# is assumed not to be dispatchable (Meeting Bechtel/EGU October 27, 1993).
```

```
# It is modeled as non-firm capacity, so does not count toward commitment
# and spinning reserve.
# Includes 120 MW owned by SEP having similar district heating
# characteristics.

distcm 1 two capacity states considered
#        J   F   M   A   M   J   J   A   S   O   N   D
        22  147 147 93  69  37  37  37  37  37  69  69  93
# UPDATED 5.11.1993
distha 1
        2   7000
distmr 1
        2  .15
distfr 1 forced outage rate
        2    0.10
distfc 1
        fc=resd
distom 1 O&M
        om=omn1
#
#
#   HYDRO PLANTS *************
#
#            *** Vah Cascade
#            *** without pumped storage Cerny Vah
#
vahchc 1 capacity varies by month
        25      .728  .702  .939 1.000  .886  .781
                 .649  .588  .500  .500  .737  .754
c total capacity (MW)
          y1992   560
vahchm 1 minimum flow varies by month
        25      .728  .702  .939 1.000  .886  .781
                 .649  .588  .500  .500  .737  .754
c total minimum flow (MW)
          y1992   133
vahche 1 energy varies by month
         20  0.083  0.080  0.107  0.114  0.101  0.089
            0.074  0.067  0.057  0.057  0.084  0.086
c total energy (GWh)
          y1992   1860
vahcfc 1 no variable cost for hydro energy
        /kwh  2  0.0

#
#            *** Gabcikovo  61.8 % for Slovakia
#
gabchc 1 capacity varies by month
         25     0.54   0.58   0.71   0.88    1.00   1.00
                 0.93   0.79   0.58   0.47    0.43   0.55
c total capacity (MW)
# This represent effective capacity reflect run-of-river operation
```

```
# and lack of reservoir.
          y1992   170
          y1993   450
gabchm 1 capacity varies by month
         25     0.54   0.58   0.71   0.88    1.00   1.00
                 0.93   0.79   0.58   0.47    0.43   0.55
c minimum capacity (MW)
          y1992   100
          y1993   340
gabche 1 energy varies by month
c average flow and total consumption from Mr.Vladimir Ondrusek
         20  0.064  0.069  0.084  0.104  0.118  0.118
            0.110  0.093  0.068  0.056  0.051  0.065
c total energy (GWh)
        y1992   222
        y1993   1900
        y1994   2173   # udaj V.Ondrusek ak prietok vody do stareho
                       # koryta bude 400 m3/s
gabcfc 1 no variable cost for hydro energy
        /kwh  2  0.0
#
#
#            *** Other Hydro
#
hydrhc 1 capacity varies by month
        25      .728  .702  .939 1.000  .886  .781
                 .649  .588  .500  .500  .737  .754
c total capacity (MW)
          y1992   40
hydrhm 1 minimum flow varies by month
         25      1.00  1.00  1.00  1.00  1.00  1.00
                  1.00  1.00  1.00  1.00  1.00  1.00
c total minimum flow (MW)
          y1992   2
hydrhe 1 energy varies by month
         20  0.083  0.080  0.107  0.114  0.101  0.089
            0.074  0.067  0.057  0.057  0.084  0.086
c total energy (GWh)
          y1992   71
hydrfc 1 no variable cost for hydro energy
        /kwh  2   0.0
#
#            *** All Pumped Storage Plants
#
pscap  1 unit 1 generating capacity (MW)
        2    735
pseff  1 efficiency (.72 gWh generation for every gWh pumped)
        2   .72
psres  1 reservoir size (gWh)
        2    350
#
#
```

```
#   GAS COMBINED CYCLE PLANTS **************

#   ******** Bratislava GCC **********

bratcm 1 net capacity (three capacity states) - slow start unit
        27  y199201   180
bratha 1 average heat rates for each capacity state
        22  8000 8000 8000 8000 8000 8000
           8000 8000 8000 8000 8000 8000
bratmu 1 number of units with SEP plan
        27  y199201  0
           y200301  1
bratmu 2 number of units without Vojany I rehabilitation
        27  y199201  0
           y200101  1
bratmu 3 number of units with Vojany I and without Vojany II rehabilitation
        27  y199201  0
           y200201  1
bratmu 31 number of units without Vojany I & II rehabilitation
        27  y199201  0
           y200001  1
bratmu 4 number of units with power purchases
        27  y199201  0
           y200601  0
bratmr 1 annual requirement, model will schedule among months
        2     0.10
bratfr 1 forced outage rate
        2    0.02
bratfc 1
        fc=ngas
bratom 1 O&M
        om=omn6
#
#            *** Senne Combined Cycle
#
senncp 1 time varying first capacity state -- nighttime shutdown
        17 y1992   25      50      63
sennha 1 average heat rates for each capacity state
        17 y1992  9902    8380    8000
sennmu 1 annual requirement, model will schedule among months
        27 y199201 0
sennmu 2 annual requirement, model will schedule among months
        27 y199201 0
          y200501 1
sennmu 31 annual requirement, model will schedule among months
        27 y199201 0
          y200301 1
sennmr 1 annual requirement, model will schedule among months
        2    0.10
sennfr 1 forced outage rate
        2   .02
sennfc 1 natural gas, cost estimates above in 'ngasfc'
```

```
        fc=ngas
sennom 1 O&M for gas-fired units
        om=omn6
#
#           *** Kosice Combined Cycle
#
kosccp 1 time varying capacity state- no shutdown
# Monthly capacity variations based on calculations by Olga Murinova
#   of EGU
        25     .9753  .9753  .9641  .9641   .9641  1.0000
                1.0000 1.0000  .9641  .9641   .9641  .9753
c total capacity (MW)
          y1992   180
koscha 1 average heat rates for each capacity state
        22  8000 8000 8000 8000 8000 8000
           8000 8000 8000 8000 8000 8000
koscmu 1 number of units with SEP plan
        27 y199201 0
          y200501 1
koscmu 2 number of units without Vojany rehabilitation
        27 y199201 0
          y200201 1
koscmu 3 number of units without Vojany rehabilitation
        27 y199201 0
          y200301 1
koscmu 31 number of units without Vojany rehabilitation
        27 y199201 0
          y200101 1
koscmu 4 number of units without Vojany rehabilitation
        27 y199201 0
          y200301 0
koscmr 1 annual requirement, model will schedule among months
        2    0.10
koscfr 1 forced outage rate
        2   .02
koscfc 1 natural gas, cost estimates above in 'ngasfc'
        fc=ngas
koscom 2 O&M for gas-fired units
        om=omn6
#
#           *** Zilina Combined Cycle
#
zilncp 1 net capacity state -- nighttime shutdown
        17 y1992     54
zilnha 1 average heat rates for each capacity state
        17 y1992     8000
zilnmu 1 number of units
        27 y199201   0
zilnmu 3 number of units
        27 y199201   0
          y200701   1
zilnmr 1 annual requirement, model will schedule among months
```

```
        2    0.10
zilnfr 1 forced outae rate
        2   .02
zilnfc 1 natural gas, cost estimates above in 'ngasfc'
         fc=ngas
zilnom 2 O&M for gas-fired units
         om=omn6
#
#            *** Martin Combined Cycle
#
martcp 1 capacity state -- nighttime shutdown
        17 y1992    63
martha 1 average heat rates for each capacity state
        17 y1992    8000
martmu 1 number of units
        27 y199201 0
martmu 3 number of units
        27 y199201 0
          y200701 1
martmr 1 annual requirement, model will schedule among months
        2    0.10
martfr 1 forced outage rate
        2    .02
martfc 1 natural gas, cost estimates above in 'ngasfc'
         fc=ngas
martom 2 O&M for gas-fired units
         om=omn6
#
#            *** Ziar Combined Cycle
#
ziarcp 1 time varying capacity state- no shutdown
# Monthly capacity variations based on calculations by Olga Murinova
#   of EGU
        25     1.0000 1.0000  .9467  .9467   .9467  .9882
                 .9882  .9882  .9467  .9467   .9467 1.0000
c total capacity (MW)
          y1992   135
ziarha 1 average heat rates for each capacity state
        17 y1992  8000
ziarmu 1 annual requirement, model will schedule among months
        27 y199201 0
ziarmu 2 annual requirement, model will schedule among months
        27 y199201 0
          y200401 1
ziarmu 3 annual requirement, model will schedule among months
        27 y199201 0
          y200601 1
ziarmu 31 annual requirement, model will schedule among months
        27 y199201 0
          y200401 1
ziarmr 1 annual requirement, model will schedule among months
        2    0.10
```


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```
ziarfr 1 forced outage rate
        2    .02
ziarfc 1 natural gas, cost estimates above in 'ngasfc'
         fc=ngas
ziarom 2 O&M for gas-fired units
         om=omn6
#
#            *** Presov Combined Cycle
#
prsvcp 1 time varying capacity state- no shutdown
# Monthly capacity variations based on calculations by Olga Murinova
#   of EGU
        25     1.0000 1.0000  .9467  .9467   .9467  .9882
                 .9882  .9882  .9467  .9467   .9467 1.0000
c total capacity (MW)
           y1992   135
prsvha 1 average heat rates for each capacity state
        22  8000 8000 8000 8000 8000 8000
            8000 8000 8000 8000 8000 8000
prsvmu 1 number of units
        27 y199201 0
prsvmu 2 number of units
        27 y199201 0
           y200301 1
prsvmu 3 number of units
        27 y199201 0
           y200501 1
prsvmu 31 number of units
        27 y199201 0
           y200201 1
prsvmr 1 annual requirement, model will schedule among months
        2    0.10
prsvfr 1 forced outage rate
        2   .02
prsvfc 1 natural gas, cost estimates above in 'ngasfc'
         fc=ngas
prsvom 2 O&M for gas-fired units
         om=omn6

#            *** Vojany Combined Cycle
#
vojncp 1 time varying first capacity state -- nighttime shutdown
        17 y1992  100     200     300
vojnha 1 average heat rates for each capacity state
        17 y1992  10000   8000    7500
vojnmu 1 annual requirement, model will schedule among months
        27 y199201 0
           y200701 1
vojnmu 2 annual requirement, model will schedule among months
        27 y199201 0
           y200701 1
vojnmu 3
```


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```
        27 y199201 0
          y200701 1
vojnmu 31
        27 y199201 0
          y200501 1
vojnmr 1 annual requirement, model will schedule among months
        2    0.10
vojnfr 1 forced outage rate
        2   .02
vojnfc 1 natural gas, cost estimates above in 'ngasfc'
         fc=ngas
vojnom 2 O&M for gas-fired units
         om=omn6
#
#
#            *** Simple Cycle
#
gastcp 1 time varying first capacity state -- nighttime shutdown
        17 y1992  100
gastha 1 average heat rates for each capacity state
        17 y1992  11000
gastmu 1
        27 y199201 0
gastmu 2
        27 y199201 0
gastmu 3
        27 y199201 0
gastmr 1 annual requirement, model will schedule among months
        2    0.10
gastfr 1 forced outage rate
        2   .02
gastfc 1 natural gas, cost estimates above in 'ngasfc'
         fc=ngas
gastom 2 O&M for gas-fired units
         om=omn6
#
#
#            *** Demand-side Management
#
dsmrde 1 Energy savings by month with 12% increase each year
        sh=dsmr 21
           0   0   0   0   0   0
           0   0   0   0   0   0
         y1993   .12
dsmrsh 1 level shape -- energy values are used to "scale" shape.
#       since this is a level shape, energy savings will result in
#       identical  capacity in all hours
         19  y1992 mon 12am 1.0
dsmrfc 1 all costs are fixed
        /kwh  2    0.0
#
#
```


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```
#           *** Interruptible Load
#
intrcp 1 87 MW of interruptible load, limited to 2% of all hours
        2   0
intrfr 1 no forced outage rate
        2   0
intrmr 1 no maintenance
        2   0
intrfc 1 $.10/kWh, escalating at 1 % per year -- per contract with
#       interruptible customers
        /kwh   1    .10   y1993  .01
intrle 1 energy (gWh) maximum 2% of all hours
        2    15.2
#
#           *** Import Power

#           First Variant - No Imports
imp1cn 1
        25      .8817  .8925  .9032  .9032   .9140  .9570
                .9140  .9140 1.0000 1.0000   .9784 1.0000
c total capacity (MW)
          y1992     0
#           Second Variant
imp1cn 2
        25      .8817  .8925  .9032  .9032   .9140  .9570
                .9140  .9140 1.0000 1.0000   .9784 1.0000
c total capacity (MW)
          y1992   500
          y1993   500
          y1994   500
          y1995     0
          y1996   200
          y1997   300
          y1998   300
          y1999     0

#           Third Variant

imp1cn 3
        25      .8817  .8925  .9032  .9032   .9140  .9570
                .9140  .9140 1.0000 1.0000   .9784 1.0000
c total capacity (MW)
          y1992   500
          y1993   500
          y1994   500
          y1995     0
          y1996   400
          y1997   400
          y1998     0

#           Fourth Variant
```

```
imp1cn 4
        25     1.000  1.000  1.000  1.000  1.000  1.000
                1.000  1.000  1.000  1.000  1.000  1.000
c total capacity (MW)
          y1992     0
          y2000   170

imp1fr 1 no forced outage rate
        2   0
imp1mr 1 no maintenance
        2   0
imp1fc 1 cost for imported energy - cost estimates above in 'imptfc'
        fc=impt

#
#           *** Emergency Import Power
#

imp2cn 1
        25     .8817  .8925  .9032  .9032   .9140  .9570
              .9140  .9140 1.0000 1.0000   .9784 1.0000
c total capacity (MW)
          y1992     300
imp2fr 1 no forced outage rate
        2   0
imp2mr 1 no maintenance
        2   0
imp2fc 1 cost for imported energy - cost estimates above in 'impefc'
        fc=impe


#
#           *** Export Power
#
#    First Variant
exptlm 1
        sh=dsmr
c total capacity (MW)
        27 y199201   -28
          y199301   -50
          y199401   -50
          y199501  -200
          y199601  -200
          y199602  -200
          y199603  -200
          y199604  -200
          y199605  -200
          y199606  -200
          y199607  -200
          y199608  -200
          y199609  -200
          y199610  -200
```

```
        y199611  -200
        y199612  -600
        y199701  -600
        y199702  -600
        y199703  -410
        y199704  -410
        y199705  -410
        y199706  -410
        y199707  -410
        y199708  -410
        y199709  -410
        y199710  -410
        y199711  -600
        y199712  -600
        y199801  -600
        y199802  -600
        y199803  -410
        y199804  -410
        y199805  -410
        y199806  -410
        y199807  -410
        y199808  -410
        y199809  -410
        y199810  -410
        y199811  -410
        y199812  -410
        y199901  -410
        y200001  -410
        y200101  -410
        y200201  -410
        y200301  -410
        y200401  -410
        y200501  -410
        y200601  -410
        y200701  -410
        y200801     0
        y200901     0
        y201001     0

c export total energy (GWh)
c       y1992  -249
c       y1993  -410
c       y1994  -400
c       y1995  -1825
c       y1996  -2060
c       y1997  -4075
c       y1998  -3840
c       y1999  -3600
c       y2000  -3600
c       y2001  -3600
c       y2002  -3600
c       y2003  -3600
```

```
c      y2004  -3600
c      y2005  -3600
c      y2006  -3600
c      y2007  -3600
c      y2008     0
c      y2009     0
c      y2010     0

#
#            ** Set User-defined Emissions Categories (here
#                 for Nitrogen Oxides, Sulfur Oxides and
#                 Carbon Dioxide)
#
emissn 1     NOx    SOx    CO2
       7   'nx'   'sx'   'co'
#
#
#            ** Set SOx rates for Coal and Oil burning plants
#
coalsx 1 based on sulfur content of fuel
       /mbtu 2   1.574
lignsx 1 based on sulfur content of fuel
       /mbtu 2   1.574
resdsx 1 based on sulfur content of fuel
       /mbtu 2   .139
ngassx 1 based on sulfur content of fuel
       /mbtu 2   .000
evo1sx 1 Vohany 1
       sx=coal
evo2sx 1 Vohany 2
       sx=resd
enoasx 1 Novaky A- 22 MW
       sx=lign
enaasx 1 Novaky A- 32 MW
       sx=lign
enobsx 1 Novaky B
       sx=lign
indysx 1 Industry-owned
       sx=resd
distsx 1 Distribution-owned
       sx=resd
sennsx 1 Senne GCC
       sx=ngas
koscsx 1 Kosice GCC
       sx=ngas
zilnsx 1 Zilina GCC
       sx=ngas
martsx 1 Martin GCC
       sx=ngas
ziarsx 1 Ziar GCC
       sx=ngas
prsvsx 1 Presov GCC
```

```
        sx=ngas
vojnsx 1 Vojany GCC
        sx=ngas
#
#
#           ** Set NOx rates for Coal, Oil and Gas burning plants
#
evo1nx 1 Vohany 1
        /mbtu 2    1.01
evo2nx 1 Vohany 2
        /mbtu 2    .532
enoanx 1 Novaky A- 22 MW
        /mbtu 2    1.01
enaanx 1 Novaky A- 32 MW
        /mbtu 2    1.01
enobnx 1 Novaky B
        /mbtu 2    1.01
indynx 1 Industry-owned
        /mbtu 2    .532
distnx 1 Distribution-owned
        /mbtu 2    .532
sennnx 1 Senne GCC
         poly/mbtu  17  y1992  0.13653  -0.00186  2.26e-05  -7.4e-08
tablnx 1 Tabli GCC
         poly/mbtu  17  y1992  0.13653  -0.00186  2.26e-05  -7.4e-08
zilnnx 1 Zilina GCC
         /mbtu      2   0.13653
martnx 1 Martin GCC
         /mbtu      2   0.13653
ziarnx 1 Ziar GCC
         /mbtu      2   0.13653
prsvnx 1 Presov GCC
         /mbtu      2   0.13653
vojnnx 1 Vojany GCC
         /mbtu      2   0.13653
#
#
#           ** Set CO2 rates for Coal, Oil and Gas burning plants
#
coalco 1 emission rate dependent on Carbon content of fuel
        /mbtu 2    213
lignco 1 emission rate dependent on Carbon content of fuel
        /mbtu 2    213
ngasco 1 emission rate dependent on Carbon content of fuel
        /mbtu 2    119
resdco 1 emission rate dependent on Carbon content of fuel
        /mbtu 2    164
evo1co 1 Vohany 1
        co=coal
evo2co 1 Vohany 2
        co=resd
enoaco 1 Novaky A- 22 MW
```

```
        co=lign
enaaco 1 Novaky A- 32 MW
        co=lign
enobco 1 Novaky B
        co=lign
indyco 1 Industry-owned
        co=resd
distco 1 Distribution-owned
        co=resd
sennco 1 Senne GCC
        co=ngas
tablco 1 Tabli GCC
        co=ngas
zilnco 1 Zilina GCC
        co=ngas
martco 1 Martin GCC
        co=ngas
ziarco 1 Ziar GCC
        co=ngas
prsvco 1 Presov GCC
        co=ngas
vojnco 1 Vojany GCC
        co=ngas
#
#
#         **Define the hourly loads (168 hours per month
#              for each typical week)
#
# ************************************************
# *    load shape data and specifications     *
# ************************************************
#
# ***** hourly load data by typical week, monday 12am through sunday 11pm
#
# Hourly load data for typical week 1 (January), 1992 (the base year)
# until changed in any later year
wk0192 1
        7
         2913 2837 2774 2727 2807 2994 3288 3331 3313 3234 3206 3241
         3203 3047 3079 3163 3376 3336 3304 3267 3170 3131 3275 3208
         3116 3030 2949 2905 2959 3107 3376 3385 3334 3247 3238 3257
         3203 3051 3107 3176 3385 3378 3337 3296 3161 3159 3285 3228
         3129 3046 2952 2917 2983 3107 3383 3393 3367 3273 3246 3266
         3217 3053 3106 3180 3380 3367 3357 3300 3189 3174 3301 3238
         3146 3050 2974 2929 2967 3102 3355 3370 3333 3259 3260 3278
         3196 3057 3088 3163 3382 3348 3338 3292 3163 3164 3303 3239
         3161 3055 2982 2930 2967 3106 3346 3377 3341 3263 3245 3242
         3169 3023 3050 3127 3340 3312 3271 3207 3102 3147 3318 3231
         3117 3003 2906 2831 2794 2667 2625 2692 2765 2826 2865 2845
         2764 2709 2712 2777 2976 2986 2960 2939 2835 3000 3157 3074
         2975 2870 2784 2711 2708 2560 2473 2543 2680 2775 2795 2714
         2605 2572 2567 2609 2829 2861 2869 2876 2773 2936 3113 3026
```

```
# Hourly load data for typical week 2 (February), 1992 (the base year)
# until changed in any later year
wk0292 1
        7
          2943 2843 2779 2738 2790 2983 3191 3253 3250 3192 3154 3165
          3152 2999 3045 3060 3151 3302 3297 3254 3125 3117 3251 3170
          3101 3019 2946 2894 2941 3092 3267 3279 3253 3206 3173 3200
          3153 2955 3022 3050 3158 3308 3325 3251 3144 3147 3263 3220
          3127 3048 2955 2897 2946 3082 3275 3295 3280 3219 3204 3234
          3179 3000 3031 3054 3181 3316 3301 3274 3145 3147 3292 3232
          3139 3069 2972 2900 2949 3069 3241 3302 3258 3187 3163 3194
          3135 3000 3005 3023 3128 3308 3311 3264 3137 3142 3294 3239
          3140 3039 2968 2912 2978 3080 3249 3295 3269 3222 3182 3190
          3112 2965 2993 2984 3098 3267 3255 3167 3064 3127 3281 3219
          3094 2998 2906 2830 2794 2667 2575 2684 2743 2807 2821 2774
          2710 2682 2673 2686 2773 2951 2969 2937 2815 2942 3134 3066
          2948 2837 2753 2683 2659 2533 2439 2538 2646 2734 2738 2657
          2547 2518 2498 2525 2594 2796 2847 2853 2731 2910 3073 2996
# Hourly load data for typical week 3 (March), 1992 (the base year)
# until changed in any later year
wk0392 1
        7
          2850 2759 2672 2638 2717 2874 3060 3155 3136 3071 3058 3074
          3058 2901 2922 2928 2956 3101 3242 3205 3079 3053 3154 3104
          2971 2891 2799 2762 2819 2917 3098 3167 3143 3074 3080 3086
          3036 2861 2910 2906 2939 3087 3229 3183 3061 3007 3132 3082
          2986 2895 2803 2756 2832 2919 3108 3174 3154 3077 3060 3087
          3056 2889 2936 2928 2943 3068 3230 3202 3089 3027 3162 3100
          2998 2908 2813 2764 2843 2914 3096 3162 3127 3073 3066 3075
          3036 2879 2915 2920 2949 3064 3212 3186 3066 3059 3174 3111
          3016 2912 2826 2790 2849 2912 3072 3141 3118 3086 3064 3067
          3000 2809 2886 2892 2886 2990 3146 3090 2978 3007 3171 3102
          2990 2865 2756 2700 2681 2521 2529 2607 2666 2727 2751 2731
          2655 2597 2598 2582 2612 2755 2905 2904 2785 2901 3032 2974
          2882 2768 2662 2614 2596 2462 2421 2493 2588 2675 2694 2597
          2497 2457 2458 2437 2458 2572 2754 2810 2723 2804 2937 2911
# Hourly load data for typical week 4 (April), 1992 (the base year)
# until changed in any later year
wk0492 1
        7
          2679 2612 2544 2501 2570 2779 3026 3034 3009 2949 2934 2964
          2915 2768 2825 2815 2805 2780 2838 3071 2978 2725 2818 2903
          2830 2754 2677 2633 2681 2860 3077 3055 3014 2948 2946 2951
          2914 2764 2805 2806 2790 2761 2792 3006 2969 2739 2840 2909
          2826 2752 2635 2605 2670 2849 3077 3055 3008 2941 2932 2945
          2899 2729 2779 2768 2788 2774 2816 3025 2969 2705 2825 2899
          2840 2755 2680 2622 2671 2827 3033 2998 2957 2900 2883 2929
          2863 2704 2765 2764 2777 2756 2797 3007 2949 2714 2836 2901
          2803 2711 2643 2593 2625 2770 2985 2948 2904 2866 2851 2860
          2782 2627 2671 2677 2672 2638 2684 2871 2827 2652 2785 2839
          2763 2689 2576 2531 2507 2422 2447 2458 2523 2574 2562 2544
          2466 2433 2429 2411 2410 2416 2469 2670 2664 2575 2693 2744
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        2612 2511 2418 2374 2363 2284 2289 2323 2419 2503 2506 2417
        2304 2267 2247 2238 2246 2256 2313 2525 2528 2473 2573 2623
# Hourly load data for typical week 5 (May), 1992 (the base year)
# until changed in any later year
wk0592 1
      7
        2276 2210 2137 2136 2153 2344 2675 2713 2721 2680 2675 2747
        2694 2532 2583 2587 2574 2555 2564 2649 2737 2535 2555 2569
        2456 2385 2310 2261 2243 2466 2749 2770 2761 2692 2693 2738
        2698 2521 2559 2571 2562 2520 2569 2649 2743 2570 2562 2564
        2486 2380 2325 2290 2279 2493 2744 2752 2761 2725 2712 2765
        2725 2559 2587 2597 2595 2553 2586 2654 2776 2581 2594 2596
        2498 2402 2331 2299 2302 2440 2729 2729 2726 2702 2681 2728
        2674 2538 2580 2586 2596 2539 2588 2657 2747 2579 2579 2590
        2473 2371 2306 2280 2260 2421 2651 2703 2695 2669 2664 2698
        2650 2493 2558 2557 2558 2513 2507 2540 2636 2522 2561 2554
        2424 2335 2248 2218 2142 2156 2228 2297 2361 2414 2422 2435
        2345 2294 2289 2288 2275 2273 2281 2364 2483 2447 2465 2453
        2340 2235 2150 2101 2055 2045 2116 2199 2311 2411 2417 2310
        2201 2155 2143 2123 2128 2115 2160 2262 2363 2322 2363 2371
# Hourly load data for typical week 6 (June), 1992 (the base year)
# until changed in any later year
wk0692 1
      7
        2248 2167 2093 2077 2093 2299 2627 2695 2710 2682 2691 2769
        2734 2562 2617 2554 2586 2545 2556 2599 2665 2560 2541 2533
        2420 2327 2262 2240 2222 2415 2686 2743 2736 2715 2712 2797
        2763 2598 2649 2617 2610 2573 2597 2630 2665 2582 2577 2551
        2449 2343 2265 2237 2228 2446 2738 2740 2734 2728 2731 2801
        2759 2606 2631 2633 2631 2593 2611 2623 2663 2604 2603 2559
        2443 2370 2283 2247 2245 2434 2671 2747 2728 2713 2712 2774
        2741 2583 2628 2634 2629 2563 2609 2647 2666 2581 2605 2571
        2462 2348 2275 2244 2233 2430 2722 2735 2732 2703 2692 2789
        2711 2564 2599 2584 2587 2552 2542 2549 2561 2522 2570 2564
        2415 2302 2214 2160 2114 2100 2198 2307 2357 2434 2453 2450
        2370 2297 2307 2284 2296 2263 2273 2300 2363 2466 2490 2447
        2282 2181 2099 2054 1991 2002 2071 2189 2322 2384 2425 2321
        2213 2163 2126 2116 2107 2122 2148 2213 2288 2356 2352 2336
# Hourly load data for typical week 7 (July), 1992 (the base year)
# until changed in any later year
wk0792 1
      7
        2116 2026 1975 1943 1967 2134 2365 2449 2490 2482 2516 2602
        2546 2426 2442 2447 2431 2371 2400 2419 2504 2434 2410 2375
        2260 2166 2113 2062 2056 2191 2436 2488 2516 2509 2526 2600
        2552 2429 2455 2434 2436 2411 2414 2422 2479 2434 2426 2368
        2271 2162 2099 2071 2074 2213 2432 2494 2518 2514 2535 2617
        2564 2427 2450 2440 2439 2385 2408 2444 2499 2439 2438 2392
        2286 2197 2137 2075 2073 2208 2401 2456 2487 2477 2514 2583
        2549 2405 2437 2419 2426 2393 2419 2443 2493 2464 2452 2405
        2276 2185 2110 2080 2074 2208 2425 2458 2485 2469 2495 2567
        2498 2384 2408 2401 2395 2354 2360 2377 2429 2402 2422 2379
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        2249 2145 2059 2010 1973 1956 2061 2162 2233 2264 2309 2319
        2246 2182 2193 2163 2167 2140 2166 2235 2300 2319 2334 2287
        2136 2040 1978 1939 1892 1885 1980 2092 2206 2311 2317 2223
        2099 2033 2008 2008 2009 1994 2045 2092 2168 2209 2223 2186
# Hourly load data for typical week 8 (August), 1992 (the base year)
# until changed in any later year
wk0892 1
      7
        2169 2103 2037 2056 2118 2262 2521 2623 2633 2635 2656 2735
        2707 2565 2604 2591 2595 2541 2566 2660 2771 2523 2517 2485
        2364 2266 2220 2197 2240 2355 2654 2688 2708 2682 2719 2770
        2745 2583 2633 2635 2614 2591 2632 2724 2777 2572 2540 2495
        2383 2293 2239 2233 2220 2384 2656 2710 2730 2703 2719 2795
        2750 2604 2634 2617 2645 2610 2616 2718 2786 2559 2554 2527
        2397 2299 2234 2243 2256 2379 2639 2688 2687 2704 2719 2761
        2702 2575 2613 2635 2621 2599 2603 2716 2776 2555 2562 2552
        2426 2300 2260 2250 2260 2371 2653 2697 2725 2699 2720 2776
        2714 2570 2601 2609 2596 2566 2550 2653 2681 2536 2547 2507
        2389 2230 2168 2136 2144 2100 2210 2280 2343 2390 2436 2387
        2331 2286 2262 2262 2250 2239 2283 2415 2475 2397 2401 2349
        2242 2123 2056 2058 2027 1973 2119 2185 2299 2401 2410 2318
        2213 2143 2108 2086 2114 2082 2161 2303 2371 2301 2311 2284
# Hourly load data for typical week 9 (September), 1992 (the base year)
# until changed in any later year
wk0992 1
      7
        2229 2165 2096 2093 2194 2453 2773 2793 2802 2753 2733 2782
        2779 2625 2651 2672 2695 2640 2765 2931 2771 2509 2550 2538
        2441 2349 2272 2263 2338 2564 2844 2845 2836 2773 2778 2840
        2761 2612 2662 2638 2657 2626 2738 2940 2783 2521 2563 2564
        2458 2347 2295 2278 2358 2601 2871 2881 2851 2805 2791 2848
        2765 2624 2639 2640 2679 2657 2770 2979 2787 2542 2582 2589
        2464 2380 2306 2279 2386 2590 2852 2852 2811 2772 2740 2803
        2761 2603 2638 2661 2644 2638 2773 2970 2806 2559 2589 2585
        2502 2415 2335 2299 2414 2594 2844 2877 2827 2766 2753 2807
        2734 2570 2603 2605 2630 2590 2721 2841 2695 2524 2568 2581
        2434 2335 2247 2209 2242 2209 2263 2353 2381 2446 2451 2448
        2368 2321 2315 2291 2304 2322 2459 2635 2499 2412 2462 2443
        2289 2200 2134 2094 2106 2078 2136 2236 2345 2413 2454 2328
        2218 2160 2156 2132 2131 2238 2379 2511 2400 2342 2373 2348
# Hourly load data for typical week 10 (October), 1992 (the base year)
# until changed in any later year
wk1092 1
      7
        2421 2338 2279 2281 2363 2585 2828 2941 2920 2854 2860 2907
        2851 2715 2746 2780 2910 3058 3056 2978 2870 2733 2815 2717
        2606 2511 2435 2417 2523 2661 2939 2990 2953 2880 2903 2943
        2886 2731 2758 2806 2926 3084 3089 3008 2892 2779 2828 2745
        2623 2524 2460 2468 2542 2707 2941 3007 2998 2914 2919 2946
        2896 2748 2798 2837 2949 3100 3088 2995 2898 2808 2866 2756
        2648 2548 2464 2473 2560 2694 2905 2965 2964 2921 2897 2942
        2895 2735 2785 2813 2947 3087 3097 3001 2940 2825 2918 2845
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        2689 2578 2521 2521 2581 2698 2945 3027 2981 2890 2910 2914
        2871 2728 2736 2786 2920 3028 2999 2917 2836 2826 2896 2797
        2638 2534 2433 2416 2427 2349 2389 2493 2539 2565 2581 2574
        2520 2453 2469 2506 2660 2806 2796 2737 2633 2670 2756 2647
        2513 2400 2329 2303 2316 2204 2235 2375 2451 2524 2534 2474
        2375 2320 2315 2299 2499 2618 2672 2649 2548 2648 2724 2620
# Hourly load data for typical week 11 (November), 1992 (the base year)
# until changed in any later year
wk1192 1
      7
        2721 2621 2540 2531 2635 2838 3083 3159 3166 3115 3102 3144
        3119 2992 3033 3129 3286 3221 3184 3113 3023 2954 3090 3016
        2914 2828 2741 2689 2752 2935 3173 3221 3217 3155 3163 3165
        3107 2977 2997 3115 3312 3229 3176 3130 3043 2995 3081 3024
        2940 2816 2722 2702 2742 2944 3189 3227 3208 3138 3120 3153
        3102 2977 3044 3118 3303 3257 3192 3121 3056 3013 3118 3033
        2927 2836 2743 2702 2760 2938 3144 3198 3172 3143 3148 3142
        3089 2961 3007 3115 3294 3239 3195 3109 3018 2963 3117 3026
        2945 2829 2757 2714 2770 2941 3150 3186 3160 3111 3088 3103
        3020 2886 2917 3027 3279 3169 3119 3034 2983 2997 3135 3054
        2902 2784 2673 2618 2609 2538 2516 2638 2655 2713 2750 2741
        2679 2639 2657 2746 2946 2904 2873 2799 2728 2828 2975 2896
        2761 2667 2557 2522 2527 2413 2359 2449 2571 2651 2696 2589
        2504 2470 2475 2574 2771 2753 2793 2768 2669 2806 2937 2878
# Hourly load data for typical week 12 (December), 1992 (the base year)
# until changed in any later year
wk1292 1
      7
        2857 2757 2685 2660 2772 2937 3196 3261 3229 3163 3148 3177
        3140 3032 3073 3259 3386 3292 3243 3191 3082 3068 3214 3140
        3048 2941 2849 2832 2861 3009 3302 3304 3258 3184 3173 3206
        3172 3046 3104 3245 3388 3301 3241 3176 3112 3101 3224 3177
        3041 2966 2884 2828 2875 3054 3305 3320 3313 3223 3224 3252
        3205 3089 3132 3241 3368 3304 3257 3224 3128 3122 3224 3152
        3051 2988 2881 2832 2892 3033 3262 3273 3262 3197 3157 3185
        3178 3048 3089 3252 3414 3276 3240 3177 3119 3120 3210 3160
        3063 2962 2909 2846 2894 3041 3260 3288 3261 3183 3158 3145
        3081 2995 3020 3173 3289 3225 3166 3099 3038 3088 3175 3130
        3041 2914 2825 2764 2725 2671 2683 2722 2787 2844 2854 2836
        2789 2753 2781 2915 3035 3010 2965 2893 2818 2918 3084 3012
        2929 2783 2696 2630 2628 2508 2455 2566 2687 2753 2773 2727
        2642 2634 2602 2717 2862 2880 2862 2837 2772 2937 3047 2967
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Case Study Output

Presented are year-by-year power plant production and the economic summary for the four considered variants with variant four having two subvariants.

Considered variants are listed bellow:

Variant 1	-	the SEP reference variant that includes rehabilitation of units 3-6 at Vojany I. Expansion assumptions are presented on slide A-73.
Variant 2	-	same as reference variant with retirement of units 3-6 at Vojany I and addition of new gas combined cycle units when needed to meet the load growth. Expansion assumptions are presented on slide A-74.
Variant 3	-	best of variants 1 & 2 with retirement of units 5-6 at Vojany II and addition of new gas combined cycle units when needed to meet the load growth. Expansion assumptions are presented on slide A-77.
Variant 4	-	same as Variant 3 with long term imports instead of first gas combined cycle unit. Imports are priced at 1.5 Sk/kWh loaded in the economic order with the same fixed cost as for GCC unit. Expansion assumptions are presented on slide A-80.
Variant 4A	-	same as Variant 3 with long term imports instead of first gas combined cycle unit. Imports are base loaded priced at 1 Sk/kWh.

Power Plant Production (GWh)

Variant 1 -- run with rehabilitation of Vojany I - SEP Plan

Year	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	Total
Bohunice V-1	5539	5278	4105	4631	5539	5540	4905	1416	0	0	0	0	36954
Bohunice V-2	5645	5357	5375	5645	5645	5357	5374	5645	5646	5356	5375	5645	66064
Mochovce 1	0	0	2607	5274	5148	5383	5692	5582	5383	5383	5691	5673	51814
Mochovce 2	0	0	0	0	0	0	607	4521	5292	5092	5681	5672	26865
Vojany 1 bl.1	1330	1353	1113	909	1113	1208	1036	1044	1307	1311	1195	1240	14159
Vojany 1 bl.3	1215	992	943	350	37	0	455	928	1265	1269	1172	1173	9799
Vojany 1 bl.5	0	0	422	891	896	978	828	758	1121	1126	1207	1128	9354
Vojany 2 b.21	1213	2141	1961	1574	1454	1575	1627	1614	1872	1813	1909	1997	20751
Vojany 2 b.25	0	169	57	174	170	373	513	463	719	722	779	779	4918
Novaky A- 22	107	108	108	108	107	107	108	108	107	108	108	108	1291
Novaky A- 32	0	99	36	23	24	35	29	0	34	34	35	34	384
Novaky B-100	199	754	583	291	336	576	764	787	819	824	868	839	7639
Novaky B- 79	179	498	231	210	239	0	0	0	0	0	0	0	1357
Vah Cascade	1860	1860	1865	1860	1860	1860	1865	1860	1860	1860	1865	1860	22336
Gabcikovo	2173	2173	2178	2173	2173	2173	2178	2173	2173	2173	2178	2173	26092
Other hydro	71	71	71	71	71	71	71	71	71	71	71	71	853
Ind.-owned	2195	2201	2250	2313	2382	2453	2535	2603	2681	2761	2854	2929	30157
Dis.-owned	515	524	524	524	503	505	523	518	514	520	525	521	6218
Tp Bratislava	0	0	0	0	0	0	0	0	0	1339	1339	1301	3979
Tp Komarno	0	0	0	0	0	0	0	0	0	0	0	0	0
Senne GCC	0	0	0	0	0	0	0	0	0	0	0	0	0
Kosice GCC	0	0	0	0	0	0	0	0	0	0	0	744	744
Zilina GCC	0	0	0	0	0	0	0	0	0	0	0	0	0
Martin GCC	0	0	0	0	0	0	0	0	0	0	0	0	0
Ziar GCC	0	0	0	0	0	0	0	0	0	0	0	0	0
Presov GCC	0	0	0	0	0	0	0	0	0	0	0	0	0
Vojany GCC	0	0	0	0	0	0	0	0	0	0	0	0	0
Imports	0	0	0	0	0	0	0	0	0	0	0	0	0
Emergency Imp	15	0	0	1	1	1	1	37	2	1	2	2	62
Exports	-438	-1752	-2054	-4139	-3861	-3592	-3601	-3592	-3592	-3592	-3601	-3592	-37405

ECONOMIC SUMMARY
(costs in 10^6 SK)

Variant 1- With rehabilitation of Vojany I -- SEP plan

Year	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	End Effects
LOLP with additions (hours/yr)	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.06	0.03	0.09	0.09	
Investment	8714	13841	18318	8459	10375	11550	7092	1796	2147	1724	956	0	-59547
Fixed O&M Costs	2952	3439	4640	5863	6186	6689	7415	8443	9554	10930	12023	13734	
Variable Operating Cost	6090	6683	6100	3747	4068	5103	5956	6366	7836	9443	10000	11030	Total System
Total Electric Cost	17757	23963	29058	18069	20628	23342	20462	16605	19537	22097	22979	24764	-59547
Heat Revenue	0	0	0	0	0	0	0	0	0	556	556	1112	
Heat Cost	0	0	0	0	0	0	0	0	0	484	498	1027	
Net Heat Benefit	0	0	0	0	0	0	0	0	0	72	58	86	
Adjusted Electric Cost	17757	23963	29058	18069	20628	23342	20462	16605	19537	22024	22921	24678	-59547
Cumulative Present Worth	16216	36201	70777	88846	109475	132817	153279	169884	189421	211445	234366	259044	132391

Present Worth of Adjusted Electric Cost 132391

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Power Plant Production (GWh)

Variant 2 -- run with retired Vojany I units 3-6

Year	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	Total
Bohunice V-1	5539	5278	4105	4631	5539	5540	4905	1416	0	0	0	0	36954
Bohunice V-2	5645	5357	5375	5645	5645	5357	5374	5645	5646	5356	5375	5645	66064
Mochovce 1	0	0	2607	5274	5148	5383	5692	5582	5383	5383	5691	5673	51814
Mochovce 2	0	0	0	0	0	0	607	4521	5292	5092	5681	5672	26865
Vojany 1 bl.1	1330	1353	1151	1054	1254	1289	1225	1148	1456	1456	1324	1368	15407
Vojany 1 bl.3	1215	992	1009	605	142	0	0	0	0	0	0	0	3963
Vojany 1 bl.5	0	0	0	0	0	0	0	0	0	0	0	0	0
Vojany 2 b.21	1213	2141	1962	1758	1701	1926	2121	1816	2071	2053	2127	2289	23177
Vojany 2 b.25	0	169	174	228	274	616	818	754	731	769	743	793	6071
Novaky A- 22	107	108	108	108	107	107	108	107	107	108	108	108	1291
Novaky A- 32	0	99	36	35	41	106	35	23	34	34	35	34	513
Novaky B-100	199	754	683	499	641	838	913	859	820	905	841	876	8826
Novaky B- 79	179	498	367	292	366	0	0	0	0	0	0	0	1703
Vah Cascade	1860	1860	1865	1860	1860	1860	1865	1860	1860	1860	1865	1860	22336
Gabcikovo	2173	2173	2178	2173	2173	2173	2178	2173	2173	2173	2178	2173	26092
Other hydro	71	71	71	71	71	71	71	71	71	71	71	71	853
Ind.-owned	2195	2201	2250	2313	2382	2453	2535	2603	2681	2761	2854	2929	30157
Dis.-owned	515	524	523	523	502	501	523	516	511	520	525	519	6203
Tp Bratislava	0	0	0	0	0	0	0	1299	1332	1362	1364	1358	6716
Tp Komarno	0	0	0	0	0	0	0	0	0	0	0	0	0
Senne GCC	0	0	0	0	0	0	0	0	0	0	0	208	208
Kosice GCC	0	0	0	0	0	0	0	0	785	1213	1175	1188	4362
Zilina GCC	0	0	0	0	0	0	0	0	0	0	0	0	0
Martin GCC	0	0	0	0	0	0	0	0	0	0	0	0	0
Ziar GCC	0	0	0	0	0	0	0	0	0	0	296	392	688
Presov GCC	0	0	0	0	0	0	0	0	0	786	611	672	2068
Vojany GCC	0	0	0	0	0	0	0	0	0	0	0	0	0
Imports	0	0	0	0	0	0	0	0	0	0	0	0	0
Emergency Imports	15	0	0	25	14	70	115	144	2	1	1	2	389
Exports	-438	-1752	-2054	-4139	-3861	-3592	-3601	-3592	-3592	-3592	-3601	-3592	-37405

ECONOMIC SUMMARY
(costs in 10^6 SK)

Variant 2 -- with retired Vojany I units 3 - 6

Year	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	End Effects
LOLP with additions (hours/yr)	0.01	0.01	0.01	0.03	0.03	0.06	0.12	0.07	0.05	0.05	0.04	0.10	
Investment	7964	12116	17343	8459	10897	12996	8692	3210	2530	1390	354	0	-62160
Fixed O&M Costs	2952	3439	4404	5483	5767	6229	6845	7910	9092	10315	11692	13050	
Variable Operating Cost	6090	6683	6251	4006	4379	5537	6379	7150	8510	10170	10672	11695	
Total Electric Cost	17007	22238	27998	17948	21042	24762	21917	18269	20132	21875	22718	24745	-62160
Heat Revenue	0	0	0	0	0	0	0	556	1112	1335	1602	1602	
Heat Cost	0	0	0	0	0	0	0	456	939	1161	1435	1478	
Net Heat Benefit	0	0	0	0	0	0	0	100	173	174	167	124	
Adjusted Electric Cost	17007	22238	27998	17948	21042	24762	21917	18169	19959	21701	22552	24621	-62160
Cumulative Present Worth	15531	39244	67243	85190	106233	130994	152911	171080	191039	212740	235292	259913	131087

Present Worth of Adjusted Electric Cost 131087

Power Plant Production (GWh)

Variant 3 -- run with retired Vojany I units 3-6 and Vojany II unit 5-6

Year	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	Total
Bohunice V-1	5539	5278	4105	4631	5539	5540	4905	1416	0	0	0	0	36954
Bohunice V-2	5645	5357	5375	5645	5645	5357	5374	5645	5646	5356	5375	5645	66064
Mochovce 1	0	0	2607	5274	5148	5383	5692	5582	5383	5383	5691	5673	51814
Mochovce 2	0	0	0	0	0	0	607	4521	5292	5092	5681	5672	26865
Vojany 1 bl.1	1330	1353	1151	1054	1254	1393	1139	1211	1487	1523	1393	1393	15680
Vojany 1 bl.3	1215	992	1009	605	142	0	0	0	0	0	0	0	3963
Vojany 1 bl.5	0	0	0	0	0	0	0	0	0	0	0	0	0
Vojany 2 b.21	1213	2141	1962	1758	1701	2057	1925	1819	2099	2205	2262	2121	23263
Vojany 2 b.25	0	169	174	228	274	0	0	0	0	0	0	0	846
Novaky A- 22	107	108	108	108	107	107	108	107	107	108	108	108	1291
Novaky A- 32	0	99	36	35	41	148	35	23	34	34	35	34	556
Novaky B-100	199	754	683	499	641	945	875	800	789	905	851	803	8743
Novaky B- 79	179	498	367	292	366	0	0	0	0	0	0	0	1703
Vah Cascade	1860	1860	1865	1860	1860	1860	1865	1860	1860	1860	1865	1860	22336
Gabcikovo	2173	2173	2178	2173	2173	2173	2178	2173	2173	2173	2178	2173	26092
Other hydro	71	71	71	71	71	71	71	71	71	71	71	71	853
Ind.-owned	2195	2201	2250	2313	2382	2453	2535	2603	2681	2761	2854	2929	30157
Dis.-owned	515	524	523	523	502	505	523	516	512	520	525	519	6208
Tp Bratislava	0	0	0	0	0	0	1230	1180	1263	1338	1337	1224	7572
Tp Komarno	0	0	0	0	0	0	0	0	0	0	0	0	0
Senne GCC	0	0	0	0	0	0	0	0	0	297	230	216	743
Kosice GCC	0	0	0	0	0	0	0	740	991	1314	1224	1111	5380
Zilina GCC	0	0	0	0	0	0	0	0	0	0	0	0	0
Martin GCC	0	0	0	0	0	0	0	0	0	0	0	0	0
Ziar GCC	0	0	0	0	0	0	0	0	0	0	414	150	564
Presov GCC	0	0	0	0	0	0	0	0	569	901	737	603	2810
Vojany GCC	0	0	0	0	0	0	0	0	0	0	0	1420	1420
Imports	0	0	0	0	0	0	0	0	0	0	0	0	0
Emergency Imp	15	0	0	25	14	206	91	134	2	3	2	1	493
Exports	-438	-1752	-2054	-4139	-3861	-3592	-3601	-3592	-3592	-3592	-3601	-3592	-37405

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ECONOMIC SUMMARY
(costs in 10^6 SK)

Variant 3 -- run with retired Vojany I units 3-6 and Vojany II unit 5-6

Year	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	End Effects
LOLP with additions (hours/yr)	0.01	0.01	0.01	0.03	0.03	0.14	0.10	0.08	0.08	0.11	0.10	0.03	
Investment	7964	12116	17343	9656	12646	13672	7802	2291	3509	3452	1500	0	-67374
Fixed O&M Costs	2952	3439	4404	5483	5767	6229	7161	8257	9378	10471	11863	13812	
Variable Operating Cost	6090	6683	6251	4006	4379	5383	6099	6718	8115	9720	10205	11116	
Total Electric Cost	17007	22238	27998	19144	22792	25284	21061	17266	21001	23642	23568	24929	-67374
Heat Revenue	0	0	0	0	0	0	556	1112	1335	1335	1602	1602	
Heat Cost	0	0	0	0	0	0	443	912	1127	1161	1435	1478	
Net Heat Benefit	0	0	0	0	0	0	113	200	208	174	167	124	
Adjusted Electric Cost	17007	22238	27998	19144	22792	25284	20948	17066	20794	23469	23401	24805	-67374
Cumulative Present Worth	15531	39244	67243	86387	109179	134462	155410	172476	193270	216738	240140	264945	132142
Present Worth of Adjusted Electric Cost			132142										

Power Plant Production (GWh)

Variant 4 -- same as variant 3 with power purchases instead of Bratislava GCC

Year	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	Total
Bohunice V-1	5539	5278	4105	4631	5539	5540	4905	1416	0	0	0	0	36954
Bohunice V-2	5645	5357	5375	5645	5645	5357	5374	5645	5646	5356	5375	5645	66064
Mochovce 1	0	0	2607	5274	5148	5383	5692	5582	5383	5383	5691	5673	51814
Mochovce 2	0	0	0	0	0	0	607	4521	5292	5092	5681	5672	26865
Vojany 1 bl.1	1330	1353	1151	1054	1254	1393	1326	1272	1564	1592	1420	1416	16123
Vojany 1 bl.3	1215	992	1009	605	142	0	0	0	0	0	0	0	3963
Vojany 1 bl.5	0	0	0	0	0	0	0	0	0	0	0	0	0
Vojany 2 b.21	1213	2141	1962	1758	1701	2057	2236	1924	2208	2329	2346	2172	24046
Vojany 2 b.25	0	169	174	228	274	0	0	0	0	0	0	0	846
Novaky A- 22	107	108	108	108	107	107	108	107	107	108	108	108	1291
Novaky A- 32	0	99	36	35	41	148	35	34	34	34	35	34	567
Novaky B-100	199	754	683	499	641	945	1055	886	1034	1033	922	838	9487
Novaky B- 79	179	498	367	292	366	0	0	0	0	0	0	0	1703
Vah Cascade	1860	1860	1865	1860	1860	1860	1865	1860	1860	1860	1865	1860	22336
Gabcikovo	2173	2173	2178	2173	2173	2173	2178	2173	2173	2173	2178	2173	26092
Other hydro	71	71	71	71	71	71	71	71	71	71	71	71	853
Ind.-owned	2195	2201	2250	2313	2382	2453	2535	2603	2681	2761	2854	2929	30157
Dis.-owned	515	524	523	523	502	505	523	516	512	520	525	520	6209
Tp Bratislava	0	0	0	0	0	0	0	0	0	0	0	0	0
Tp Komarno	0	0	0	0	0	0	0	0	0	0	0	0	0
Senne GCC	0	0	0	0	0	0	0	0	0	393	350	269	1012
Kosice GCC	0	0	0	0	0	0	0	958	1172	1331	1314	1192	5968
Zilina GCC	0	0	0	0	0	0	0	0	0	0	0	0	0
Martin GCC	0	0	0	0	0	0	0	0	0	0	0	0	0
Ziar GCC	0	0	0	0	0	0	0	0	0	0	745	477	1222
Presov GCC	0	0	0	0	0	0	0	0	747	930	858	676	3211
Vojany GCC	0	0	0	0	0	0	0	0	0	0	0	1805	1805
Imports	0	0	0	0	0	0	426	204	337	800	467	171	2405
Emergency Imp	15	0	0	25	14	206	99	139	2	3	2	1	505
Exports	-438	-1752	-2054	-4139	-3861	-3592	-3601	-3592	-3592	-3592	-3601	-3592	-37405

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ECONOMIC SUMMARY
(costs in 10^6 SK)

Variant 4 -- same as variant 3 with power purchases instead of Bratislava GCC

Year	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	End Effects
LOLP with additions (hours/yr)	0.01	0.01	0.01	0.03	0.03	0.14	0.11	0.07	0.08	0.11	0.10	0.04	
Investment	7964	12116	17343	8459	10850	12676	7802	2291	3509	3452	1500	0	-64341
Fixed O&M Costs	2952	3439	4404	5483	5767	5948	6852	7918	9004	10060	11411	13315	
Variable Operating Cost	6090	6683	6251	4006	4379	5383	6011	6574	8054	9709	10186	11051	
Total Electric Cost	17007	22238	27998	17948	20996	24006	20665	16783	20566	23221	23097	24366	-64341
Heat Revenue	0	0	0	0	0	0	0	556	779	779	1046	1046	
Heat Cost	0	0	0	0	0	0	0	456	658	677	937	965	
Net Heat Benefit	0	0	0	0	0	0	0	100	121	101	109	81	
Adjusted Electric Cost	17007	22238	27998	17948	20996	24006	20665	16683	20445	23119	22988	24286	-64341
Cumulative Present Worth	15531	39244	67243	85190	106186	130192	150857	167539	187985	211104	234092	258378	129402

Present Worth of Adjusted Electric Cost 129402

Power Plant Production (GWh)

Variant 4A -- same as variant 4 with base power purchases 1 Sk/kWh

Year	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	Total
Bohunice V-1	5539	5278	4105	4631	5539	5540	4905	1416	0	0	0	0	36954
Bohunice V-2	5645	5357	5375	5645	5645	5357	5374	5645	5646	5356	5375	5645	66064
Mochovce 1	0	0	2607	5274	5148	5383	5692	5582	5383	5383	5691	5673	51814
Mochovce 2	0	0	0	0	0	0	607	4521	5292	5092	5681	5672	26865
Vojany 1 bl.1	1330	1353	1151	1054	1254	1393	1139	1140	1449	1518	1378	1384	15542
Vojany 1 bl.3	1215	992	1009	605	142	0	0	0	0	0	0	0	3963
Vojany 1 bl.5	0	0	0	0	0	0	0	0	0	0	0	0	0
Vojany 2 b.21	1213	2141	1962	1758	1701	2057	1910	1730	2057	2206	2262	2107	23103
Vojany 2 b.25	0	169	174	228	274	0	0	0	0	0	0	0	846
Novaky A- 22	107	108	108	108	107	107	108	107	107	108	108	108	1291
Novaky A- 32	0	99	36	35	41	148	35	34	34	34	35	34	567
Novaky B-100	199	754	683	499	641	945	906	848	867	981	911	833	9065
Novaky B- 79	179	498	367	292	366	0	0	0	0	0	0	0	1703
Vah Cascade	1860	1860	1865	1860	1860	1860	1865	1860	1860	1860	1865	1860	22336
Gabcikovo	2173	2173	2178	2173	2173	2173	2178	2173	2173	2173	2178	2173	26092
Other hydro	71	71	71	71	71	71	71	71	71	71	71	71	853
Ind.-owned	2195	2201	2250	2313	2382	2453	2535	2603	2681	2761	2854	2929	30157
Dis.-owned	515	524	523	523	502	505	523	516	512	520	525	520	6209
Tp Bratislava	0	0	0	0	0	0	0	0	0	0	0	0	0
Tp Komarno	0	0	0	0	0	0	0	0	0	0	0	0	0
Senne GCC	0	0	0	0	0	0	0	0	0	255	214	207	676
Kosice GCC	0	0	0	0	0	0	0	736	823	1215	1178	999	4951
Zilina GCC	0	0	0	0	0	0	0	0	0	0	0	0	0
Martin GCC	0	0	0	0	0	0	0	0	0	0	0	0	0
Ziar GCC	0	0	0	0	0	0	0	0	0	0	385	107	492
Presov GCC	0	0	0	0	0	0	0	0	563	821	645	589	2618
Vojany GCC	0	0	0	0	0	0	0	0	0	0	0	1332	1332
Imports	0	0	0	0	0	0	1493	1489	1489	1489	1493	1489	8943
Emergency Imp	15	0	0	25	14	206	99	139	2	3	2	1	505
Exports	-438	-1752	-2054	-4139	-3861	-3592	-3601	-3592	-3592	-3592	-3601	-3592	-37405

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ECONOMIC SUMMARY
(costs in 10^6 SK)

Variant 4A -- same as Variant 4 with base power purchases 1 Sk/kWh

Year	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	End Effects
LOLP with additions (hours/yr)	0.01	0.01	0.01	0.03	0.03	0.14	0.10	0.09	0.08	0.11	0.10	0.03	
Investment	7964	12116	17343	8459	10850	12676	7802	2291	3509	3452	1500	0	-64341
Fixed O&M Costs	2952	3439	4404	5483	5767	5948	6536	7570	8622	9640	10949	12807	
Variable Operating Cost	6090	6683	6251	4006	4379	5383	7064	7706	9036	10576	11059	11943	
Total Electric Cost	17007	22238	27998	17948	20996	24006	21402	17568	21167	23667	23508	24750	-64341
Heat Revenue	0	0	0	0	0	0	0	556	779	779	1046	1046	
Heat Cost	0	0	0	0	0	0	0	456	658	677	937	965	
Net Heat Benefit	0	0	0	0	0	0	0	100	121	101	109	81	
Adjusted Electric Cost	17007	22238	27998	17948	20996	24006	21402	17467	21046	23566	23399	24669	-64341
Cumulative Present Worth	15531	39244	67243	85190	106186	130192	151595	169062	190108	213674	237073	261742	130898
Present Worth of Adjusted Electric Cost			130898										