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DEMAND-SIDE MANAGEMENT IN POLAND:
PART 1: NATIONAL ASSESSMENT

Final Report

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ABSTRACT

This report presents the results of work sponsored by the Bureau for Europe of the United States Agency for International Development (USAID). Through a bilateral program, USAID has been providing assistance to the Government of Poland under the Eastern Europe Regional Energy Efficiency Project. One of the project's tasks included a national assessment of the potential for demand-side management (DSM) in Poland, which is the topic of this part (Part 1) of the report. The results of the national DSM assessment provide a means for the Polish Power Grid Company (PPGC) and other Polish organizations to identify investments in DSM resources that could be financed through power sector loans from multilateral development banks and other financial institutions. This report presents the following results:

1) **Electricity use in Poland is described by predominate end-uses in each customer class.** The report documents where and how system and customer load shape changes are required to meet PPGC's strategic objectives. This approach provides a new type of load forecasting in which end-use load research is used to characterize customer consumption patterns and future requirements.

2) **The economic DSM potential was calculated, based on a "DSM supply curve" that shows how much savings can be achieved by DSM technologies at what cost.** Fifty eight candidate measures were "screened" or ranked for consideration in DSM program development, including two innovative rate measures (time-of-use and interruptible rates). From this screening, twenty five measures (excluding the rate measures) were considered to be cost-effective, resulting in an economic potential of 25,400 GWh per year or roughly 26 percent of current consumption.

3) **The achievable DSM potential was determined, based on benefit/cost analyses of candidate DSM programs.** Utility DSM programs were defined that could be undertaken to implement the cost-effective measures identified in the technology screening process described above. In addition to the installed capital and operating costs of the DSM measures, the utility's program administration costs (overhead, marketing, implementation, and evaluation) were included. Likely market penetration rates were also modeled. Benefit/cost analyses of the programs were then performed using the total resource cost and societal cost tests. Finally, the energy and demand impacts of cost-effective DSM programs were calculated.

4) **The likely market penetration of DSM in Poland was projected, based on an assessment of DSM impacts and Polish economic and energy consumption trends.** The achievable energy savings potential of DSM is 1,738 GWh per year, equivalent to 8 percent of incremental energy requirements. The achievable demand savings potential of DSM is 552 MW, equivalent to 17 percent of incremental demand requirements, which would displace all of the planned capacity additions in Poland through 2000. Thus, DSM would be equivalent to the 18th-largest power plant in Poland in energy terms and the 14th-largest in capacity terms.

ACRONYMS

ACEEE	American Council for an Energy-Efficient Economy
ASD	adjustable speed drive
CFL	compact fluorescent lamp
CHP	combined heat and power
C&I	commercial and industrial
CSC	cost of conserved capacity
CSE	cost of conserved energy
DSM	demand-side management
EPRI	Electric Power Research Institute
ERA	Energy Regulatory Agency
ESCO	energy service company
FEWE	Polish Foundation for Energy Efficiency - Fundacja na Rzecz Efeletywnego Wykorzystania Energii
GDP	gross domestic product
GOP	Government of Poland
HVAC	heating, ventilation, and air conditioning
I&C	interruptible and curtailable
IRP	integrated resource planning
MDB	multilateral development bank
OECD	Organization for Economic Cooperation and Development
PPGC	Polish Power Grid Company - Polskei Sieci Elektroenergotyczne
RFP	request for proposals
SPEC	Warsaw District Heating Company
T&D	transmission and distribution
TOU	time of use
TRC	total resource cost
USAID	United States Agency for International Development
WB	World Bank

SKRÓTY

ACEEE	American Council for an Energy-Efficient Economy Amerykańska Rada ds. Gospodarki Efektywnie Wykorzystującej Energię
ASD	adjustable speed drive napęd o regulowanej predkości
CFL	compact fluorescent lamp kompaktowa lampa jarzeniowa
CHP	combined heat and power produkcja enegii cieplnej i elektrycznej w skojarzeniu
C&I	commercial and industrial dotyczący lokali niemieszkalnych i przemysłu
CSC	cost of conserved capacity koszt zaoszczędzonej mocy
CSE	cost of conserved energy koszt zaoszczędzonej energii
DSM	demand-side management sterowanie popytem
EPRI	Electric Power Research Institute Instytut Badawczy Elektroenergetyki
ERA	Energy Regulatory Agency Agencja Regulacyjna Energetyki
ESCO	energy service company energetyczna firma usługowa
FEWE	Polish Foundation for Energy Efficiency Fundacja na Rzecz Efektywnego Wykorzystania Energii
GDP	gross domestic product produkt krajowy brutto
GOP	Government of Poland Rząd Polski
HVAC	heating, ventilation and air conditioning ogrzewanie, wentylacja i klimatyzacja
I&C	interruptible and curtailable podlegający przerwom i ograniczeniu dostaw
IRP	integrated resource planning zintegrowane planowanie źródeł
MDB	multilateral development bank wielostronny bank rozwoju

OECD	Organization for Economic Cooperation and Development Organizacja na Rzecz Współpracy i Rozwoju Gospodarczego
PPGC	Polish Power Grid Company Polskie Sieci Elektroenergetyczne S.A.
RFP	request for proposals zaproszenie do składania ofert
SPEC	Warsaw District Heating Company Stołeczne Przedsiębiorstwo Energetyki Cieplnej
T&D	transmission and distribution przesył i rozdział
TOU	time of use pora zużycia energii
TRC	total resource cost całkowity koszt źródła
USAID	United States Agency for International Development Agencja Stanów Zjednoczonych ds. Rozwoju Międzynarodowego
WB	World Bank Bank Światowy

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EXECUTIVE SUMMARY

PROJECT BACKGROUND AND OBJECTIVES

This report presents the results of work sponsored by the Bureau for Europe of the United States Agency for International Development (USAID). Through a bilateral program, USAID has been providing assistance to the Government of Poland (GOP) under the Eastern Europe Regional Energy Efficiency Project. One of the project's tasks included work on demand-side management in Poland, which is the topic of this report.

The GOP initiated the Energy Sector Restructuring, Privatization, and Regulatory Reform Program in 1991. The program was developed in coordination with the World Bank, and involves assistance from several bilateral donors, including USAID. To encourage the most economically efficient allocation of resources within a free market framework, the Energy Sector Restructuring Program includes a least-cost planning component. True least-cost planning, also known as integrated resource planning (IRP), entails the evaluation of both supply- and demand-side resources to identify the mix of resources that yield the least cost to society. Supply-side resources consist of the conventional generation, transmission, and distribution facilities. Demand-side resources, on the other hand, include measures or programs that modify the timing and level of consumer demand. IRP therefore extends the domain of utility planning and resources beyond the distribution system to the customer side of the meter.

Demand-side management (DSM) is the identification, use, and evaluation of demand-side resources. DSM is achieved through ***energy efficiency***, which is the reduction of kilowatt hours (kWh) of energy consumption or ***load management***, which is the reduction of kilowatts (kW) of power demand or the displacement of demand to off-peak times. It encompasses a broad range of measures to encourage consumers to voluntarily modify their electricity consumption without compromising service quality or customer satisfaction. Tariffs can be designed to stimulate a shift in consumption to off-peak periods. End-use energy efficiency can reduce both energy and peak power demand. Direct load control can likewise limit peak power demand.

The GOP is coordinating several activities to develop the least-cost plan. A USAID Electricity Transfer Pricing and Retail Tariff Study is underway to formulate an electricity pricing strategy. The formulation of a potential supply-side development plan has begun with assistance from Austrian and French teams. This study complements those efforts by

identifying and assessing potential demand-side resources for Poland. The overall objectives of this project are to:

- identify demand-side management programs that should be considered within the context of a least-cost power system plan
- evaluate the costs and benefits of these programs
- assist Polish authorities in developing a lasting institutional capability, within government, the utilities, and the private sector, to design, implement, and evaluate DSM programs on a continuing basis.

This two-part report describes the activities of the project and presents the findings and recommendations of the study. Part 1 discusses a national assessment of DSM in Poland, while Part 2 describes a proposed industrial DSM and end-use load research pilot program.

SCOPE OF THE DSM ASSESSMENT

DSM will find a place in Poland's least-cost plan only if it is shown to be ***economically justified*** from a social perspective as well as ***financially viable*** for both utilities and consumers. However, financial viability will depend upon the power sector regulations and revised tariffs, which are still being prepared. Because programs cannot be designed (e.g., with respect to rebate levels) to meet utility and consumer criteria until these regulations and tariffs are in place, this assessment focuses only on the economic justification for DSM.

In any case, the economic analysis of DSM is the first step towards developing a DSM program. If DSM cannot be shown to be economically justified, then subsequent financial analysis is not warranted. If DSM programs are shown to be economically justified, then this analysis can serve as the foundation for subsequent financial analysis, program refinement, and the formulation of regulations that will make economically justified programs financially viable.

Moreover, this economic analysis is required if DSM is to be considered for multilateral development bank (MDB) financing. While MDBs would also require a financial analysis for the appraisal of a full-scale implementation project, it is expected that economic analysis alone will be sufficient for the appraisal of a pilot project. The financial dimensions of the pilot project would be addressed once the new energy sector regulations and tariffs are in

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place, probably after the loan is appraised. This report has therefore been prepared with the analytical rigor necessary to support the loan appraisal process.

Exhibit S-1 illustrates the scope of this analysis. As noted above, DSM redefines the boundaries of utility planning to include the customer. Chapter 2 of this report characterizes electricity consumption in Poland at both the customer and the end-use levels. The Institute of Power Engineering in Katowice has provided customer class load shapes, while the Polish Foundation for Energy Efficiency has provided information on the types of end-use technologies currently in use and the number of installations.

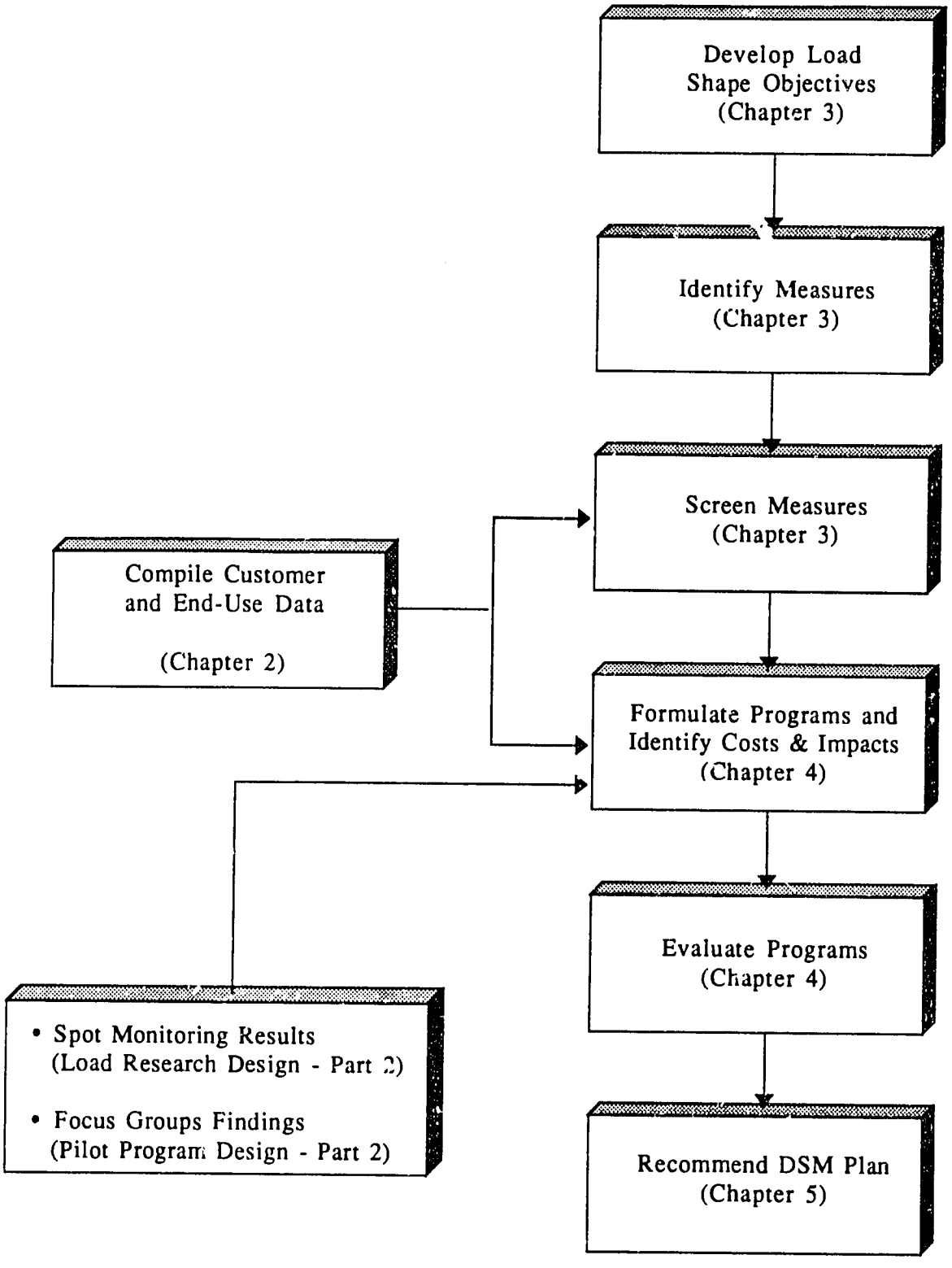
Chapter 3 opens with a discussion of the load shape objectives for DSM in Poland. Just as expected changes in load shapes can guide the selection of new supply options (e.g., whether a peaking or baseload unit is called for), DSM programs can be designed to achieve particular load shape objectives. Given that capacity additions are expected in Poland as early as 1996, that extensive plant rehabilitation may begin even sooner, and that there may be relatively high environmental costs associated with conventional coal-fired generation, this study examines potential DSM programs for conservation and peak-clipping.

Numerous measures are available in all sectors to achieve these objectives. Chapter 3 also identifies industrial, commercial, and residential measures that are suitable for Poland. In order to screen out less promising measures, the cost of conserved energy is calculated for each measure and compared to the avoided energy cost. This screening is carried out using the technology and end-use data described in Chapter 2. These measures are ordered by cost to provide an energy efficiency supply curve. Only measures with a cost of conserved energy less than the avoided generation cost are retained for further consideration. The total energy savings associated with the cost-effective measures is referred to as the "economic potential" of the measures.

Measures must be packaged with marketing, delivery, and evaluation mechanisms in order to become actual demand-side resources. Without marketing and delivery, measures would never be installed; without evaluation, the contribution of the resource to power sector needs cannot be determined. These packages constitute DSM programs. Chapter 4 describes how these measures can be developed into programs, the costs of doing so, and the expected participation and load impacts of the resulting programs.

The information needed for this is drawn from data presented in Chapter 2 as well as the findings of the focus groups conducted as part of the pilot program design and the spot load monitoring carried out as part of the load research design. These activities are described in further detail in Part 2 of this report. Economic benefit/cost ratios are then calculated for

Exhibit S-1. Elements of the DSM Assessment



each program. The load impact of those programs that are economically justified is referred to as the "achievable potential," which takes into account the gradual growth of program penetration.

Chapter 5 presents a recommended national DSM plan. This plan is a realistic assessment of the cost-effective demand-side resources that could be implemented in Poland to meet consumer needs at least cost in a near-term DSM project. The chapter also presents an economic analysis of the entire plan in terms that could be used to support the appraisal of the DSM component of an MDB loan to Poland. Chapter 5 concludes with an overview of the next steps required to further develop demand-side resources in Poland: the design and implementation of a DSM pilot program and the formulation of a supportive regulatory framework.

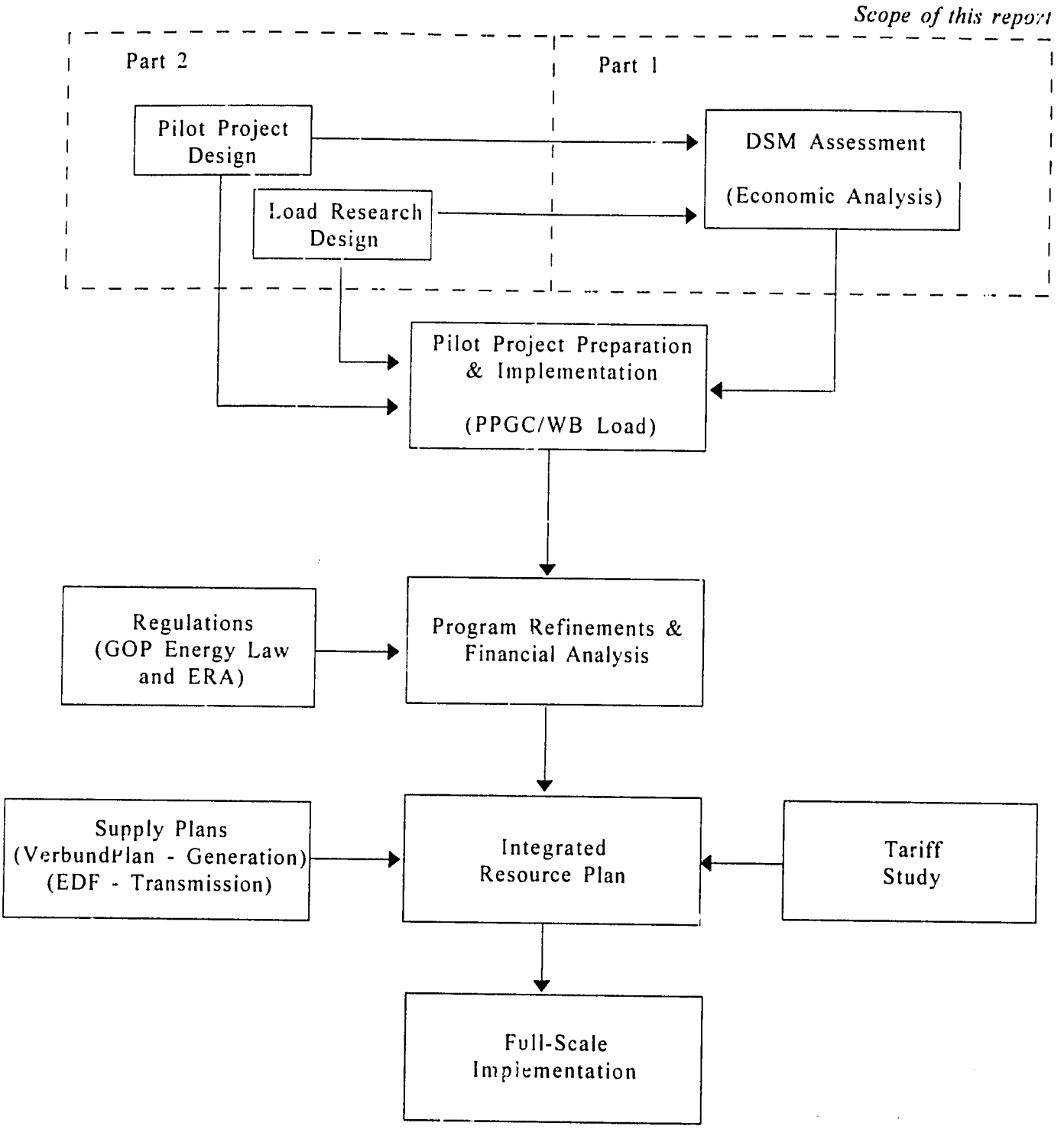
The DSM assessment is just one element of a comprehensive power sector restructuring program. Exhibit S-2 illustrates how this study fits into the broader restructuring effort. The results of this assessment and the load research and pilot program design activities aim to provide the basis for an MDB-financed DSM pilot effort. As energy regulations are formulated in Poland, further work will be necessary to conduct the financial analysis needed to refine the programs and ensure they are attractive to both utilities and consumers. This task need not wait until the pilot program has been implemented, but preliminary results from the pilot program could be taken into account as they become available. The final programs can then be introduced into the IRP analysis, which will also draw on the Supply Plan Study and the Tariff Study.

IDENTIFYING DEMAND-SIDE RESOURCES

Just as utility system needs dictate the selection of supply-side technologies, demand-side resources can only be defined in terms of system requirements. The assessment describes those system requirements in terms of load shape objectives, and identifies potential technical measures to meet those objectives. These measures are screened for economic viability by comparing the cost of saved energy for each measure with the avoided generation cost. Measures that pass this screening form the basis for programs described and assessed with DSManager in Chapter 4.

Some of the salient points regarding the Polish power system that help determine the appropriate load shape objectives are summarized below:

Exhibit S-2. The Role of the DSM Assessment



- New generation capacity additions are expected in Poland as early as 1996, despite a decline in electricity sales over the past few years. Extensive plant rehabilitation is also expected over the 1993-2000 time period. Peak clipping, load shifting, and flexible load shapes can obviate or defer capacity additions and rehabilitation needs.

- Approximately 99.5 percent of Poland's electricity is produced from coal- or lignite-fired plants. Although the employment impacts of reduced coal and lignite consumption should be taken into account, the use of these fuels has considerable environmental costs. Electricity conservation would help reduce these costs (and may offer net employment growth as well if carried out through a properly designed DSM program).

- New transmission and distribution capacity additions are planned for the next several years. Approximately one-half of the value of a system peak coincident kilowatt of demand at the low-voltage level is attributable to transmission and distribution capacity. Conservation and peak clipping would help reduce or defer transmission and distribution additions.

- Load factor for the Polish grid is currently around 65 percent. This is an above-average load factor, which suggests that prospects for increasing the load factor are limited at best. The benefits of higher capacity utilization would not likely outweigh the economic costs of valley filling.

Although the IRP analysis will ultimately judge the value of particular demand-side resources, the above points suggest that the DSM measures most appropriate for Poland are those which reduce peak demands and save energy.

Measures to improve electric end-use efficiency and better manage peak load will vary with the sector and end-use. The search for appropriate measures focused on the following sectors and end-uses:

- *Residential:* lighting, refrigeration, and water heating. These end-uses account for approximately 79 percent of residential consumption, or about 22 percent of total consumption.

- *Commercial:* lighting. This end-use accounts for 60 percent of commercial consumption, or 6 percent of total consumption.

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- *Industrial:* lighting and motors, although some measures will address overall industrial use. Lighting and motors alone account for about 80 percent of industrial demand, or 42 percent of total consumption.

- *Street lighting:* this end-use accounts for about 1 percent of consumption.

Thus, this assessment considers measures that target end-uses accounting for about 71 percent of total consumption.

Exhibit S-3 shows the annual energy consumption and total installed end-use capacity for each principal end-use for which DSM measures were considered. The values for some of these targeted end-uses are lower than for total end-use since certain end-use applications, e.g., very large motors, were not included in the analysis. Information on the costs and savings of candidate measures was used to calculate the cost of saved energy (CSE, the levelized incremental cost of the measure per kilowatt-hour of conserved energy) and the cost of saved capacity (CSC, the levelized incremental cost of the measure per kilowatt of saved generation, transmission, and distribution capacity).

Exhibit S-3
Energy Consumption and Installed Capacity by Targeted End-Use

End-Use	Annual Energy Consumption (GWh)	% of Total Sector	Total Installed End-Use Capacity (MW)
Residential			
Lighting	14,550	55%	13,250
Refrigerators	5,412	21%	3,288
Water Heaters	1,160	4%	-
Commercial			
Lighting[1]	5,321	54%	2,163
Industrial			
Motors[2]	29,771	58%	11,173
Lighting[3]	4,507	9%	1,132

[1] Does not include 540 GWh of consumption associated with specialty lighting for which measures were not considered.
[2] Does not include 5,971 GWh of consumption and 1,440 MW of end-use capacity associated with very large motors (average size 1,200 kW) for which measures were not considered.
[3] Does not include 598 GWh of consumption associated with specialty lighting for which measures were not considered.

Measures with a CSE below the avoided energy cost (including environmental costs) were listed along with their total potential savings in ascending cost order to yield an energy conservation supply curve. Upon review, it was found that there were no measures which passed on a CSC basis that did not also pass on a CSE basis. Therefore, only the energy conservation supply curve is presented (see Exhibit S-4).

Out of 58 measures initially identified, 25 measures pass the initial screening test. If all of these measures were implemented for all eligible customers or end-use devices, the energy savings would total 25,400 GWh per year, or 26.4 percent of 1991 total domestic electricity sales. This is referred to as the economic DSM potential, which is not considered to be a realistic assessment because it is based solely on technology costs and assumes 100 percent adoption of DSM measures in all relevant end-uses. For this reason, the achievable DSM potential is calculated as a more realistic assessment that takes into account the costs of DSM programs and the likely market penetration rates of DSM measures. For example, the achievable potential in Poland for DSM programs that could be implemented through the year 2000 is estimated to be 1,738 GWh per year.

BENEFITS AND COSTS OF DSM PROGRAMS

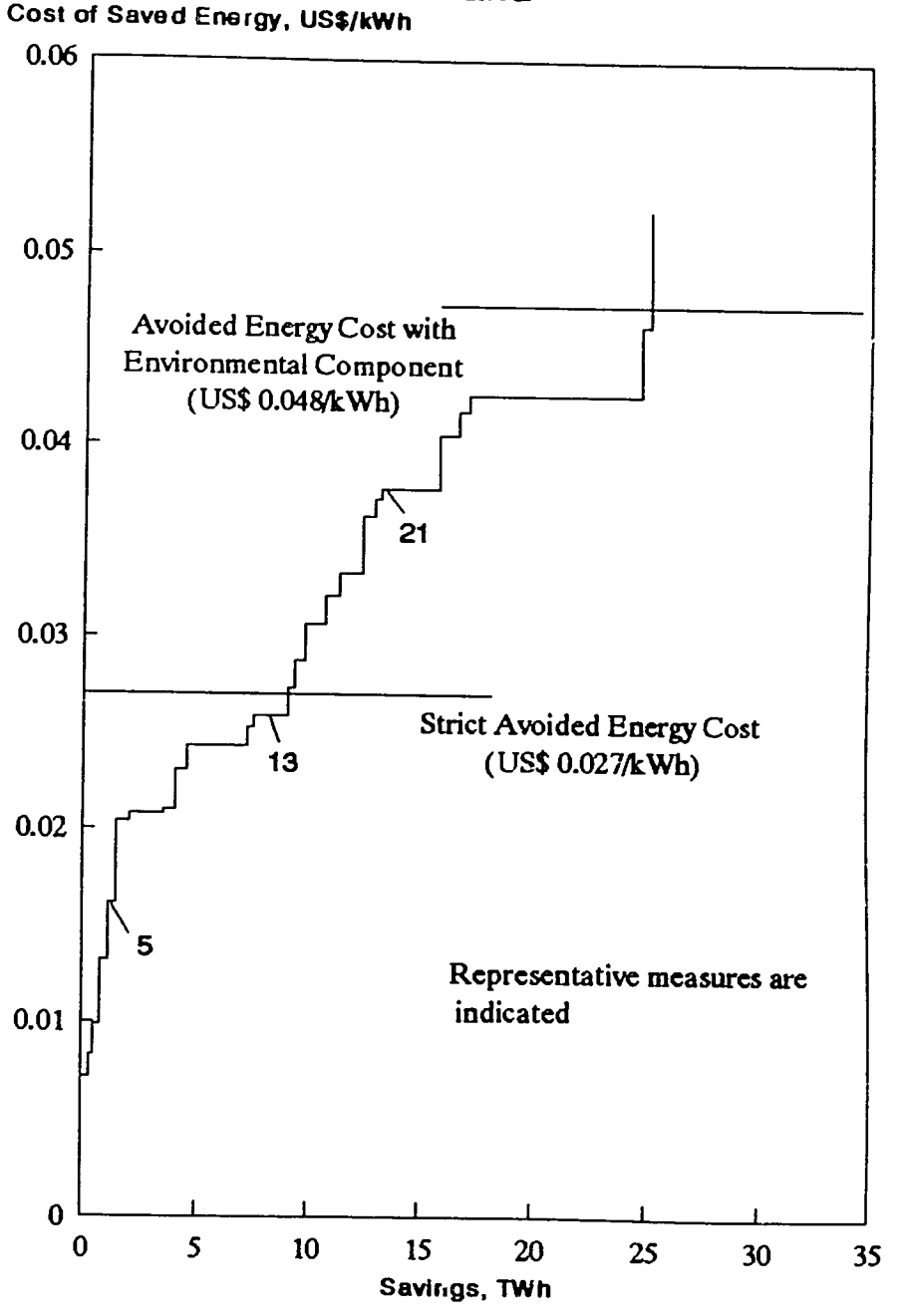
DSM measures cannot install themselves at the customers' premises; their economic potential will not be realized unless steps are taken to market and implement these measures. The assessment identifies DSM programs that would result from packaging the measures with marketing, delivery, and evaluation mechanisms. The programs described in this report are only illustrative of the scope and benefits of programs that may be adopted in Poland. Further design work is necessary to specify in detail programs appropriate for full-scale implementation in Poland.

An important aspect of the assessment of DSM programs in Poland is that the operation and impacts of the programs are limited to six years (1995 to 2000), which is a fairly short time period. For example, many other regional DSM assessments have typically run for fifteen years. The emphasis in this report on immediate project possibilities, rather than long-term strategic potential, highlights options currently available to Polish energy planners that are suitable for multilateral development bank financing. Since this is a conservative approach which does not provide a comprehensive evaluation of the long-term potential of DSM in Poland, the cumulative potential impact of DSM in Poland is understated. As utilities and customers become familiar with the operations and benefits of DSM programs, administrative

Exhibit S–4: Energy Conservation Supply Curve for Poland

Measure	Cost of Saved Energy	Savings
1 Replace 17.5 kW hi–use motors with hi–eff. motors upon rewind	$0.007 per kWh	336 GWh
2 Replace 120 kW hi–use motors with hi–eff. motors upon rewind	$0.008 per kWh	170 GWh
3 Replace 3.5 kW hi–use motors with hi–eff. motors upon rewind	$0.010 per kWh	257 GWh
4 Retrofit 120 kW hi–use motors with ASDs	$0.013 per kWh	368 GWh
5 Replace 120 kW low–use motors with hi–eff. motors upon rewind	$0.016 per kWh	350 GWh
6 Replace small refigerators (approx. 150 l) upon retirement with 1990 US average	$0.020 per kWh	557 GWh
7 Replace large refigerators (approx. 230 l) upon retirement with 1990 US average	$0.021 per kWh	1,496 GWh
8 Replace 17.5 kW low–use motors with hi–eff. motors upon rewind	$0.021 per kWh	518 GWh
9 Retrofit 17.5 kW hi–use motors with ASDs	$0.023 per kWh	537 GWh
10 Wrap water heaters	$0.024 per kWh	116 GWh
11 Industrial maintenance	$0.024 per kWh	2,552 GWh
12 Retrofit mercury vapor streetlights with high pressure sodium	$0.025 per kWh	314 GWh
13 Optimize production processes through process monitoring	$0.026 per kWh	1,531 GWh
14 Retrofit industrial mercury vapor lights with high pressure sodium	$0.027 per kWh	299 GWh
15 Replace 3.5 kW low–use motors with high efficiency motors upon rewind	$0.029 per kWh	441 GWh
16 Retrofit hi–use commercial incandescent lamps with CFLs	$0.031 per kWh	924 GWh
17 Retrofit 120 kW low–use motors with ASDs	$0.032 per kWh	605 GWh
18 Retrofit low–use commercial incandescent lamps with CFLs	$0.033 per kWh	1,037 GWh
19 Replace hi–use comm. fluorescent lamps & ballasts with T–8 systems upon retirement	$0.036 per kWh	532 GWh
20 Motor downsizing	$0.037 per kWh	271 GWh
21 Retrofit hi–use residential incandescent bulbs with CFLs	$0.038 per kWh	2,850 GWh
22 Retrofit hi–use industrial fluorescent lamps & ballasts with T–8 systems	$0.040 per kWh	888 GWh
23 Occupancy sensors	$0.042 per kWh	440 GWh
24 Retrofit low–use residential incandescent lamps with CFLs upon retirement	$0.043 per kWh	7,632 GWh
25 Retrofit high wattage industrial incandescent lamps with metal halide	$0.046 per kWh	378 GWh
	Total	25400 GWh

Industrial rate programs have not been included in this screening analysis.



costs will come down and participation rates will go up, increasing the potential impact of DSM as an electric resource in Poland into the next century.

The DSM programs are presented with a description of the program, a discussion of the assumptions made regarding participation rates and administrative costs, and resulting load shape impacts. Participation rates were calculated separately for each DSM program analyzed, reflecting the unique technical circumstances addressed by each DSM measure. The methodology first determined an eligible population of participants for which a particular measure is technically feasible or applicable as a fraction of the total population. This estimate of "feasibility/applicability" ranged from a low of 5 percent of the total population for the residential refrigeration program to a high of 90 percent for high-pressure sodium lamps in the industrial lighting program. The second step of the methodology was to estimate the fraction of the eligible population that would actually participate in the program over the six-year period of the analysis. This estimate of "market penetration" ranged from a low of 5 percent for the industrial motor downsizing program to a high of 100 percent for the street lighting program. The result of the methodology is then a cumulative final market penetration for each program in the year 2000.

Administrative costs were estimated at three levels. Within any DSM program, each technology will incur an administrative cost which can be calculated on a per-measure or per-customer basis. The variable costs at the measure level vary widely depending on the technology, type of program, and mix of resources devoted to program design, implementation, and evaluation. In this study, these variable administrative costs were estimated for Poland based on the type of program being evaluated and local labor costs. Administrative costs are also accrued at the program level. These costs are required to design, market, manage, implement, track and evaluate each program. These costs are often fixed overheads which are incurred whether the program has 1,000 or 10,000 participants. As with variable costs, fixed program overheads were estimated based on Polish labor rates and the size and duration of each program. Finally, to capture the administrative costs that are incurred in undertaking DSM on a national scale, the assessment also accounts for fixed administrative overhead pertaining to the cost of establishing a DSM group within each of Poland's fifteen distribution companies. Each distribution company will require these resources to strategically plan and coordinate DSM programs throughout all sectors within each service territory. These overheads would accrue whether the distribution companies actually deliver the programs or not, and regardless of the number or size of programs they administer.

The following DSM programs were analyzed in this assessment for Poland:

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Residential Sector

- lighting
- refrigeration
- water heating

Commercial Sector

- lighting

Industrial Sector

- motors
- drives (adjustable-speed drives and drive applications)
- motor downsizing
- industrial operations optimization
- lighting
- innovative rates

Public Sector

- street lighting

Exhibit S-5 aggregates the costs and savings associated with the preceding programs. National administrative costs are also included in this exhibit.

Exhibit S-5
National DSM Program Summary

	1995	1996	1997	1998	1999	2000
Capital Cost (000)*	$9,445	$15,287	$29,426	$37,960	$46,930	$47,043
Administrative Cost (000)	$6,984	$6,579	$10,363	$11,975	$12,672	$9,819
Energy Savings (GWh)	117	317	685	1,088	1,489	1,738
Peak Demand Savings (MW)	32	92	193	314	447	554

* Capital costs incurred by current participants and O&M costs incurred by current or previous-year participants. Lighting costs are levelized.

The assessment summarizes the benefit/cost ratios for each program and plan, as well as the net benefits, the cost of saved energy, and the cost of saved capacity. These results show that all programs and plans are economically justified even with zero environmental costs. The ratio of DSM benefits to costs in Poland could be substantially underestimated if the environmental benefits of DSM are omitted from the benefit/cost analysis. This is particularly true in the case of Poland, which relies nearly entirely on coal for electricity production, and much of this coal has a high sulfur content which can be especially damaging to the environment and human health.

A number of countries, most notably Germany and the United States, are attempting to internalize the environmental externality benefits and costs of electricity production by quantifying these values and formally integrating them into the resource acquisition process. Multilateral banks are starting to incorporate environmental costs in the appraisal of new projects to address environmental assessment requirements.

Some methodologies used to quantify environmental externalities are based on the cost of pollution control equipment that would be required to mitigate damaging environmental impacts. Other approaches attempt to quantify the cost of those impacts in terms of damage to the environment and to public health and the costs to society in terms of environmental remediation and/or lost productivity and health costs. In both cases, environmental externality costs estimated to date are generic values, not directly related to the circumstances of a specific geographic situation.

For this study, three environmental cost estimates were considered. The first, no valuation at all, set the lower end of the range to zero. Two other estimates, one developed in Germany and another in the United States, are based on the cost of pollution control equipment to mitigate stack emissions from power plants. These estimates are particularly appropriate since a significant portion of power sector borrowing requirements in Poland has been earmarked for environmental controls necessary to meet environmental regulations. The estimates were combined with data on emissions in Poland in 1990 to arrive at a US$/kWh estimate of environmental externality costs in Poland. The German estimate established a high point of the range at US$ 0.042/kWh. The U.S. estimate established a mid-point on the range at US$ 0.021/kWh, which was the value used to calculate the environmental costs avoided by DSM in this study.

Environmental costs were used twice in the analysis. First, they were added to avoided energy costs for the initial screening of measures. This "coarse" screening allows a larger number of measures to be considered in the benefit/cost analysis of DSM programs.

However, none of the measures which passed the screening were subsequently rejected in the benefit/cost analysis. Second, environmental costs were considered in the societal benefit/cost test. However, the results are also presented for the total resource cost test, which means that the benefits and costs of the DSM programs can be considered both with and without environmental costs.

The benefit/cost ratio of the entire plan is 1.87 without environmental costs, and 2.66 with environmental costs. Although some programs have benefit/cost ratios greater than 5, most are in the 1.1 to 3.0 range with environmental costs set to zero. These results are based on streams of benefits and costs that often go beyond the lifetime of the program since measures installed during the program yield savings during their entire lifetime, which is usually longer than the program.

Most of the parameter values used in this assessment have been adopted with a high level of confidence. If anything, the values of parameters such as measure savings are conservative since they are often based on extensive research conducted in the United States, where the energy consumption difference between standard and high-efficiency equipment may not be as great as it is in Poland. Avoided energy and capacity costs have been taken from the preliminary estimates derived in the draft Tariff Study. The costs of conventional equipment and measures are taken in many cases from actual price sheets or technology surveys.

The values used for capital costs, load impacts, environmental costs, administrative costs, and participation rates are, however, more uncertain. Sensitivity analysis was carried out to determine whether this uncertainty in these values could affect the economic justification for these programs.

Values for each of these parameters were represented as probability distributions, and the resulting distributions for the benefit/cost ratios were calculated using Monte Carlo simulation techniques. For administrative costs, it was assumed that actual costs would lie between 90 percent and 140 percent of the baseline costs with 70 percent confidence, and would lie between 80 percent and 200 percent of baseline costs with 99 percent confidence.

For participation rates, it was assumed that actual participation would lie between 70 percent and 110 percent of the baseline participation with 70 percent confidence, and would lie between 30 percent and 120 percent of baseline participation with 99 percent confidence.

To account for uncertainty in the load impacts of the program as well as in program capital costs, capital costs and load impacts were assumed to lie between 80 percent and 120 percent

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of their baseline values with 70 percent confidence, and between 50 percent and 150 percent of their baseline values with 99 percent confidence.

The sensitivity analysis revealed that the resulting distribution of benefit/cost ratios remained entirely greater than 1 for most plans and programs. This analysis suggests that the results of this assessment are valid over a wide range of parameter values.

IMPLEMENTING DSM AS A COMPONENT OF POWER SECTOR RESTRUCTURING

The analysis conducted with DSManager demonstrated the cost-effectiveness of selected DSM programs in Poland. Moreover, these demand-side resources represent a significant power sector resource. This significance is expressed below in both physical and economic terms.

Exhibit S-6 presents a summary of the energy and demand savings in Poland in 2000 that could be achieved from the implementation of the DSM programs described in Chapter 4. The achievable energy savings potential is 1,738 GWh per year, equivalent to 8 percent of incremental energy requirements. The achievable demand savings potential is 552 MW, equivalent to 17 percent of incremental demand requirements, which would displace all of the planned capacity additions through 2000 called for in the Supply Plan. Assuming average auxiliary and network losses of 16.3 percent, the DSM program would be equivalent to the 18th-largest power plant in Poland in energy terms and the 14th-largest in capacity terms. There are 55 dedicated thermal power plants in Poland and approximately 400 generating units overall.

The economic importance of this DSM program is commensurate with its physical significance. The economic present value of the complete program laid out in this report is US $159 million.

The costs of a DSM program are typically paid for by participating customers and the utility (non-participating consumers often pay indirectly through changes in the tariff structure). A multilateral development bank loan could be used to finance a portion of the utility costs of a DSM program. The allocation of these costs between the different parties cannot be determined until a regulatory framework is in place. Moreover, some of these costs only displace costs the consumers would have otherwise paid for electricity had they not participated in the program. Therefore, Exhibit S-5 should not be interpreted as suggesting a

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Exhibit S-6
Summary of Achievable Energy and Demand Savings in Poland in the Year 2000

PROGRAM	Energy (GWh)	Demand (MW)	Share of Incremental Energy (1995-2000)*	Share of Incremental Demand (1995-2000)**
Residential Lighting	267	48	1.2%	1.5%
Residential Refrigeration	65	8	0.3%	0.2%
Residential Water Heating	11	2	0.1%	0.1%
RESIDENTIAL SUBTOTAL	**343**	**58**	**1.6%**	**1.8%**
Commercial Lighting	225	36	1.1%	1.3%
COMMERCIAL SUBTOTAL	**225**	**36**	**1.1%**	**1.3%**
Industrial Motors	401	64	1.8%	2.0%
Drives	68	10	0.3%	0.3%
Motor Downsizing	7	1	0.0%	0.0%
Industrial Process	171	28	0.8%	0.9%
Industrial Lighting	256	44	1.2%	1.4%
Industrial Rates	59	258	0.0%	7.9%
INDUSTRIAL SUBTOTAL	**962**	**405**	**4.4%**	**12.5%**
Street Lighting	208	53	1.0%	1.6%
PUBLIC SECTOR SUBTOTAL	**208**	**53**	**1.0%**	**1.6%**
TOTAL SAVINGS	**1,738**	**552**	**8.1%**	**17.2%**

Note: totals may not add because they have been rounded.
* Incremental energy growth is calculated from the Electric Power Tariff Study: Polish Power Grid Company, Draft Report, February 1993.
**In the modeling exercise, incremental demand growth between 1995 and 2000 is calculated as 3,253 MW.

DSM loan amount or the precise use of loan funds. It does, however, conclusively demonstrate the economic justification for DSM lending.

Clearly, DSM has a place among Poland's power system options for the coming decade and beyond. Power sector restructuring efforts currently underway in Poland should take into account the potential contribution of demand-side resources. The IRP analysis will define the role of DSM with more precision. In the meantime, two activities should be carried out to further enhance the prospects for DSM in Poland.

The legal and regulatory framework under which the power sector operates in Poland should ensure that the IRP is the most profitable plan for the utility as well as the least-cost plan for its customers and society at large. The following broad themes that would support the implementation of IRP and DSM are discussed in the assessment:

- the purpose of integrated resource planning
- development of an integrated resource plan
- authority for the Polish Power Grid Company to implement the integrated resource plan
- recovery by the distribution companies of DSM costs through electric rates
- ability of the distribution companies to earn financial incentives to implement DSM
- provision for public involvement.

While the formulation and implementation of a regulatory framework is a necessary foundation for the subsequent development of demand-side resources, further information on customer response to DSM, training of Polish utility staff, and technical proof of concept are all required if widespread implementation is to take place. A pilot DSM project can accomplish all of these objectives.

Because the industrial sector offers both the greatest achievable savings potential as well as the most cost-effective programs, it is the primary candidate for a pilot project. Part 2 of this report presents in detail a pilot project suitable for financial support from multilateral development banks.

STRESZCZENIE

INFORMACJE WSTĘPNE I CELE PROGRAMU

Niniejszy raport przedstawia rezultaty prac sponsorowanych przez Biuro Europy Agencji Stanów Zjednoczonych ds. Rozwoju Międzynarodowego (USAID). USAID udziela pomocy Rządowi Polski w ramach Regionalnego Programu Efektywnego Wykorzystania Energii w Europie Wschodniej. Jednym z zadań tego programu była praca nad zagadnieniem sterowania popytem w Polsce, co stanowi przedmiot niniejszego raportu.

Rząd Polski zainicjował restrukturyzację sektora energetycznego, prywatyzację i program reformy przepisów regulacyjnych w roku 1991. Program został opracowany we współpracy z Bankiem Światowym i przewiduje pomoc kilku organizacji, między innymi USAID. W celu umożliwienia najbardziej wydajnej ekonomicznie alokacji zasobów w warunkach wolnego rynku program restrukturyzacji sektora energetycznego uwzględnia element planowania w oparciu o najniższe koszty. Prawdziwe planowanie w oparciu o najniższe koszty, określane również jako zintegrowane planowanie źródeł, obejmuje ocenę źródeł zarówno po stronie podaży, jak i popytu, tak by określić taki procentowy udział obydwu rodzajów źródeł, który wiązałby się z najmniejszymi kosztami dla społeczeństwa. Źródła po stronie podaży to konwencjonalne podsystemy wytwarzania, przesyłu i rozdziału. Natomiast źródła po stronie popytu to przedsięwzięcia lub programy modyfikujące porę oraz poziom zapotrzebowania odbiorc ≤ w. Dlatego też zintegrowane planowanie źródeł w przedsiębiorstwie energetycznym rozszerza sferę planowania i identyfikowania źródeł poza system rozdziału na odbiorcę znajdujacego się po drugiej stronie licznika.

Sterowanie popytem (DSM) to identyfikowanie, wykorzystywanie i ocena źródeł (zasobów) po stronie popytu. DSM osiąga się poprzez efektywne wykorzystywanie energii, czyli redukcję kilowatogodzin (kWh) zużycia energii elektrycznej, lub sterowanie obciążeniem, czyli zmniejszenie kilowatów (kW) obciążenia lub przesunięcie obciążenia na okresy poza szczytem. DSM obejmuje szeroki zakres działań mających na celu zachęcenie odbiorcy do zmiany profilu zużycia energii elektrycznej bez obniżania jakości obsługi lub satysfakcji odbiorcy. Taryfy można tak opracować, by stymulowały przesunięcie zużycia na godziny poza szczytem. Efektywne wykorzystywanie energii przez odbiorców finalnych może zmniejszyć zarówno zużycie energii, jak i zapotrzebowanie na moc. Bezpośrednia kontrola obciążenia w podobny sposób może ograniczyć szczytowe zapotrzebowanie na moc.

Rząd Polski koordynuje kilka działań zmierzających ku opracowaniu planu opartego o najniższe koszty. Obecnie USAID sponsoruje prace nad studium cen wewnętrznych i taryf detalicznych na energię elektryczną, które określi strategię kalkulacji cen na enegię elektryczną.

Formułowanie potencjalnego planu rozwoju strony podaży zostało rozpoczęte przy pomocy zespołów z Austrii i Francji. Niniejsze opracowanie stanowi uzupełnienie powyższych działań określając i oceniając potencjalne źródła po stronie popytu w Polsce. Ogólne cele niniejszego programu to:

- określenie programów sterowania popytem, które powinny zostać rozważone w kontekście planu systemu elektroenergetycznego opartego o najniższe koszty
- oszacowanie kosztów i korzyści związanych z takimi programami
- pomoc polskim władzom w wypracowaniu trwałych zdolności instytucjonalnych w ramach rządu, przedsiębiorstw energetycznych i sektora prywatnego pozwalających na kontynuację planowania, wdrażania i oceny programów DSM

Niniejszy dwuczęściowy raport opisuje działania podejmowane w trakcie realizacji programu oraz przedstawia jego rezultaty i wypracowane zalecenia. W Części 1 omówiona została ogólnokrajowa ocena DSM w Polsce, natomiast Część 2 opisuje proponowany pilotowy program DSM w przemyśle oraz badania obciążenia w wybranych kategoriach finalnego zużycia energii.

ZAKRES OCENY DSM

DSM znajdzie miejsce w polskim planie opartym o najniższe koszty tylko wówczas, jeśli wykazane zostanie, że jest on ekonomicznie uzasadniony z punktu widzenia społeczeństwa oraz finansowo opłacalny zarówno dla przedsiębiorstw energetycznych jak i dla odbiorców energii. Finansowa opłacalność będzie jednak zależeć od przepisów regulacyjnych w sektorze elektroenergetycznym oraz od nowych taryf, które są nadal w trakcie przygotowywania. Ponieważ do momentu wprowadzenia w życie nowych przepisów i taryf nie da się opracować programów odpowiadających kryteriom przedsiębiorstw energetycznych i odbiorców (np. w zakresie poziomów bonifikat), niniejsza ocena koncentruje się tylko na ekonomicznym uzasadnieniu DSM.

W każdym przypadku, ekonomiczna analiza DSM jest pierwszym krokiem ku opracowaniu programu DSM. Jeśli nie da się wykazać, że DSM znajduje uzasadnienie ekonomiczne, to przeprowadzona następnie analiza finansowa nie daje pełnej gwarancji. Jeśli natomiast wykazane zostanie, że programy DSM są ekonomicznie uzasadnione, to taka analiza może służyć za podstawę kolejnej analizy - tym razem analizy finansowej. Na jej podstawie można także dokonać udoskonalenia programu oraz sformułować przepisy regulacyjne, które zapewnią, że ekonomicznie uzasadnione programy staną się finansowo opłacalne.

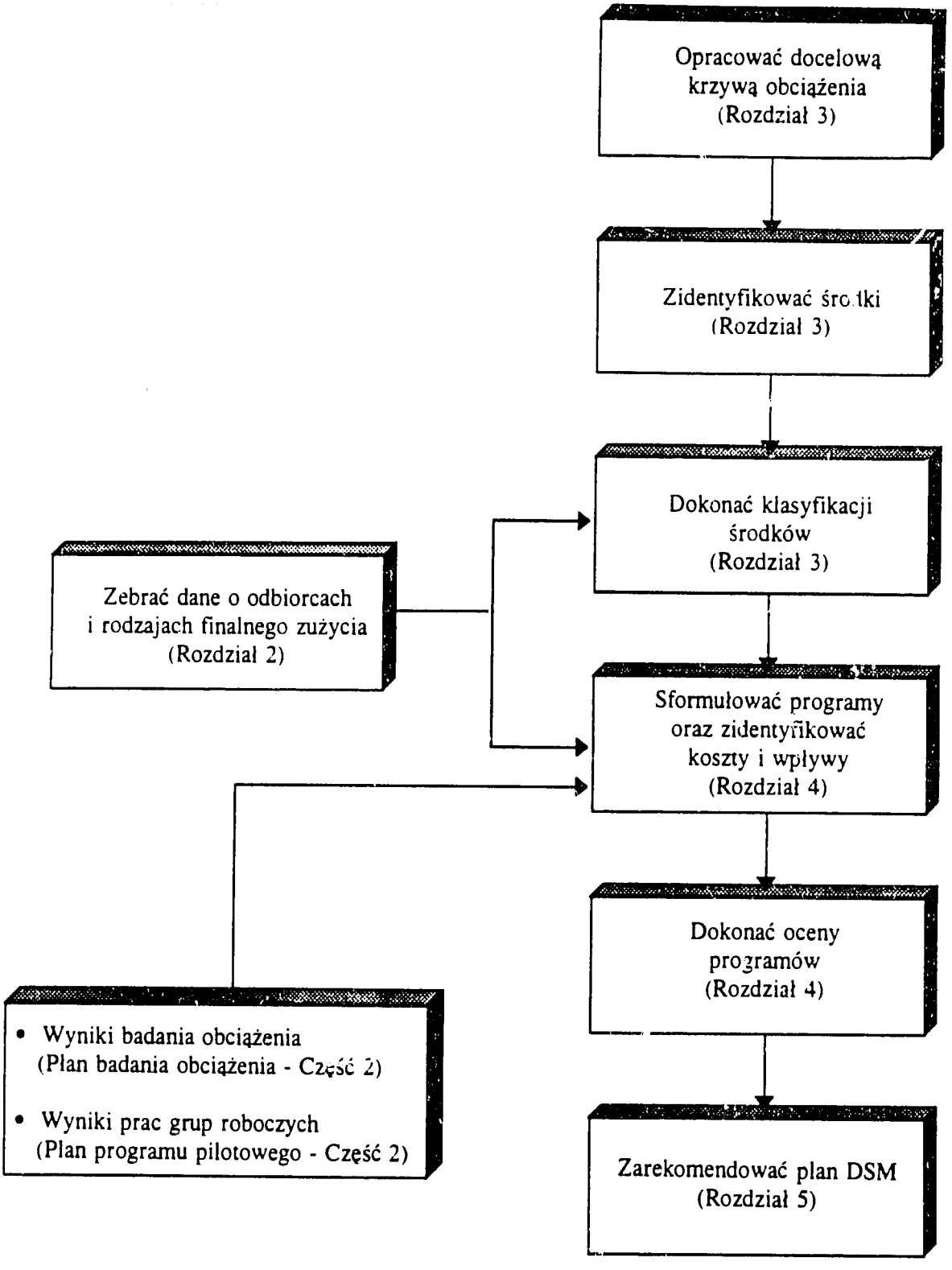
Co więcej, taka analiza ekonomiczna stanie się konieczna, jeśli DSM miałby być finansowany przez jeden z wielostronnych banków rozwoju (multilateral development bank). Choć banki takie wymagałyby również analizy finansowej dla oceny pełnego programu wdrożeniowego, to można oczekiwać, że sama analiza ekonomiczna wystarczy dla oceny programu pilotowego. Finansowe wymiary programu pilotowego zostałyby określone dopiero po wprowadzeniu nowych przepisów regulacyjnych dla sektora elektroenergetycznego i nowych taryf, prawdopodobnie po dokonaniu oceny pożyczki. Dlatego niniejszy raport został przygotowany z zachowaniem rygoru analitycznego koniecznego dla wsparcia procesu oceny pożyczki.

Schemat S-1 ilustruje zakres tej analizy. Jak wspomniano powyżej, DSM zmienia granice planowania w przedsiębiorstwie energetycznym rozszerzając je na odbiorcę energii. Rozdział 2 niniejszego raportu charakteryzuje zużycie energii elektrycznej w Polsce zarówno na poziomie odbiorcy energii, jak i na poziomie kategorii finalnego zużycia energii elektrycznej. Instytut Energetyki w Katowicach udostępnił krzywe obciążenia w poszczególnych klasach odbiorców, a Fundacja na Rzecz Efektywnego Wykorzystania Energii przekazała informacje na temat technologii stosowanych w wybranych kategoriach finalnego zużycia energii elektrycznej oraz liczby odbiorników.

Rozdział 3 zaczyna się od przedstawienia celów DSM w Polsce w zakresie kształtu krzywej obciążenia. Podobnie jak oczekiwane zmiany krzywej obciążenia mogą dyktować wybór opcji po stronie dostaw energii (np. czy należy uruchomić blok szczytowy czy pracujący w podstawie), tak programy DSM mogą być tak ukształtowane, by osiągnąć poszczególne cele w zakresie kształtu krzywej obciżenia. Mając na uwadze, że uruchomienie nowych mocy stanie się konieczne w Polsce już w roku 1996, że obszerny plan modernizacyjny może rozpocząć się jeszcze wcześniej, oraz że produkcja energii w konwencjonalnych źródłach opalanych węglem może wiązać się ze stosunkowo wysokimi kosztami środowiskowymi, niniejsze opracowanie bada potencjalne programy DSM mające na celu oszczędzanie energii i obcinanie szczytów ubciążenia.

Cele te można zrealizować przy pomocy licznych środków we wszystkich kategoriach odbiorców. W rozdziale 3 zidentyfikowane zostały środki dla odbiorców przemysłowych, lokali niemieszkalnych i gospodarstw domowych, które są odpowiednie do zastosowania w Polsce. W celu wyeliminowania mniej obiecujących środków, dla każdego z nich obliczono koszt zaoszczędzonej energii i porównano z unikniętym kosztem energii. Taki proces eliminacji jest przeprowadzany przy zastosowaniu technologii i danych na temat finalnego zużycia energii opisanych w rozdziale 2. Żrodki te zostają uszeregowane według kosztów dając krzywą efektywnego wykorzystania energii. W dalszych rozważaniach zostają uwzględnione tylko te środki, przy których koszt zaoszczędzonej energii jest mniejszy niż uniknięty koszt wytwarzania. Całkowita ilość zaoszczędzonej energii związanej ze środkami efektywnymi pod względem kosztów jest określana jako "potencjał ekonomiczny" środków.

Schemat S-1
Elementy oceny DSM



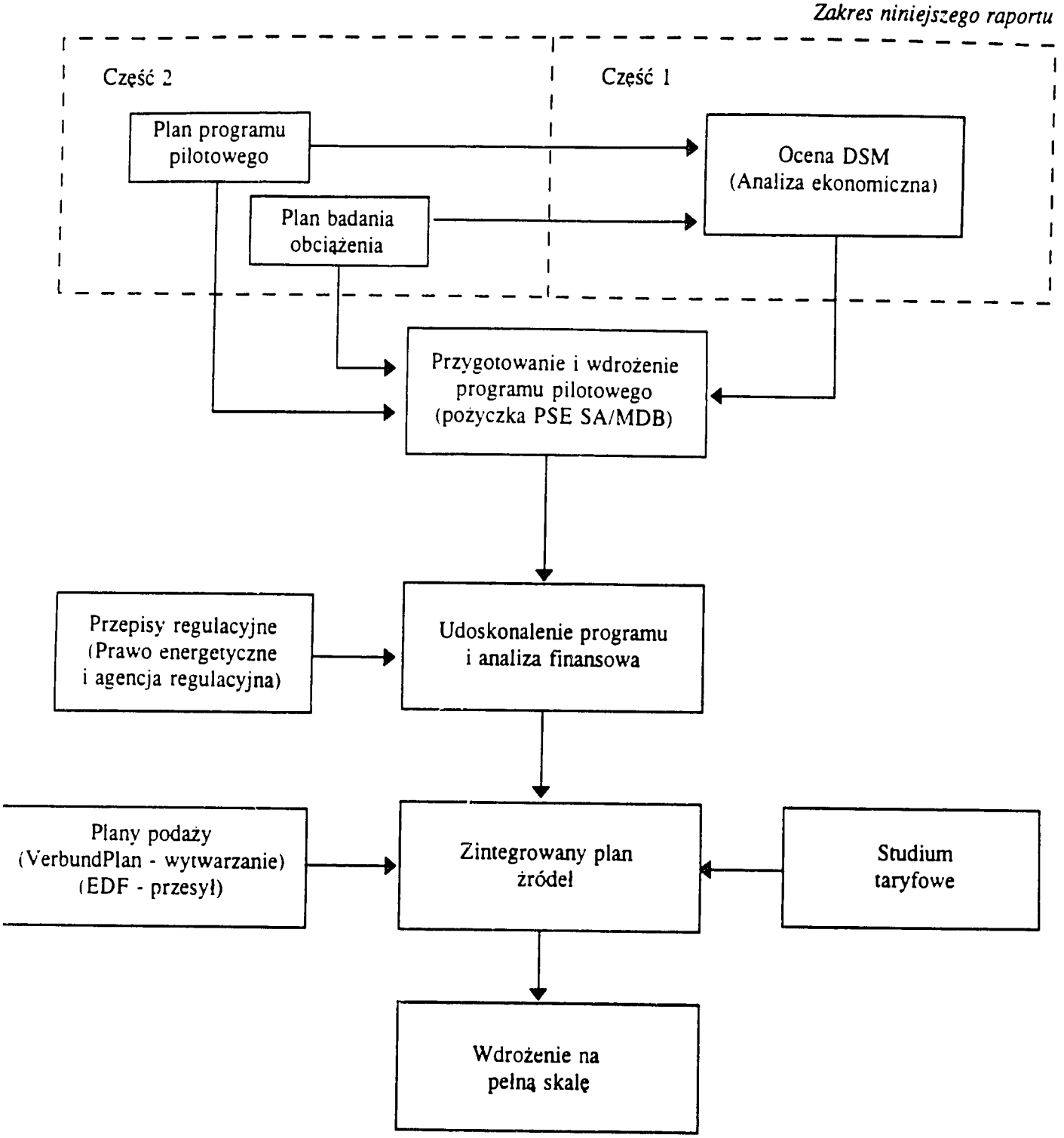
Aby środki stały się rzeczywistymi śródłami po stronie popytu muszą one zostać połączone z mechanizmami marketingu, dostarczenia do odbiorcy i oceny. Bez marketingu i dostarczenia do odbiorcy środki nigdy nie zostałyby wdrożone; natomiast bez oceny nie da się określić wkładu żródła w potrzeby sektora elektroenergetycznego. Takie połączone pakiety stanowią programy DSM. Rozdział 4 opisuje jak takie środki mogą zostać rozwinięte w programy, jakie są tego koszty, jaka jest oczekiwana liczba odbiorców uczestniczących w programach oraz spodziewany wpływ programów na krzywą obciążenia.

Informacje potrzebne w tym celu uzyskuje się z danych przedstawionych w rozdziale 2, z wyników pracy grup roboczych, które spotykały się w ramach programu pilotowego oraz z wyników pomiarów obciążenia będących częścią badań obciążenia. Działania te są przedstawione bardziej szczegółowo w Części 2 niniejszego raportu. Następnie dla każdego programu oblicza się ekonomiczne współczynniki korzyści do kosztów. Wpływ, jaki ekonomicznie uzasadnione programy mają na krzywą obciążenia, określa się jako "osiągalny potencjał", który uwzględnia stopniowo rosnący zakres zasięgu programów.

W rozdziale 5 przedstawiony jest zalecany ogólnokrajowy plan DSM. Plan ten jest realistyczną oceną kosztowo efektywnych śródeł po stronie popytu, które można byłoby wdrożyć w Polsce w celu sprostania potrzebom odbiorcy po najniższych kosztach w krótkoterminowym programie DSM. Rozdział ten przedstawia również ekonomiczną analizę całego planu w sposób, który mógłby zostać wykorzystany dla wsparcia oceny DSM będącego elementem pożyczki wielostronnego banku rozwoju dla Polski. Rozdział 5 kończy się przeglądem kolejnych kroków koniecznych dla dalszego rozwoju śródeł po stronie popytu w Polsce: zaplanowania i wdrożenia programu pilotowego DSM oraz sformułowania służących temu ram regulacyjnych.

Ocena DSM jest tylko jednym z elementów wszechstronnego programu restrukturyzacji sektora elektroenergetycznego. Schemat S-2 ilustruje jak prace nad oceną DSM są powiązane z szerszymi działaniami restrukturyzacyjnymi. Wyniki tej oceny oraz działania w zakresie badania obciążenia i ukształtowania programu pilotowego mają na celu stworzenie podstawy dla pilotowych działań DSM finansowanych przez jeden z wielostronnych banków rozwoju. Po sformułowaniu przepisów regulacyjnych w Polsce konieczne będzie przeprowadzenie analizy finansowej, która udoskonali programy i zapewni, że będą one atrakcyjne zarówno dla przedsiębiorstw energetycznych, jak i odbiorców energii. Zadanie to nie musi czekać do chwili wdrożenia programu pilotowego, lecz wstępne wyniki takiego programu mogą zostać uwzględnione gdy tylko będą one znane. Wówczas będzie możliwe uwzględnienie ostatecznych programów w analizie zintegrowanego planowania śródeł, korzystającej również z wyników Studium Planowania Podaży i Studium Taryfowego.

Schemat S-2
Rola oceny DSM



ROZPOZNANIE ŹRÓDEŁ PO STRONIE POPYTU

Tak jak system elektroenergetyczny musi dyktować wybór technologii wytwarzania, przesyłu i rozdziału, tak śródła po stronie popytu mogą zostać zdefiniowane wyłącznie w kategoriach wymagań systemowych. Ocena opisuje takie wymagania systemowe w kategoriach docelowej krzywej obciążenia oraz określa potencjalne techniczne środki pozwalające na osiągnięcie takiego celu. Żrodki te są następnie analizowane pod względem ich opłacalności ekonomicznej poprzez porównanie kosztów energii zaoszczędzonej w wyniku zastosowania każdego ze środków z unikniętymi kosztami wytwarzania. Żrodki, które pomyślnie przejdą przez taką analizę, tworzą podstawę programów opisanych i ocenionych przy pomocy programu komputerowego DSManager w rozdziale 4.

Poniżej podsumowane są niektóre charakterystyczne czynniki związane z polskim systemem elektroenergetycznym, które pomagają określić odpowiednie cele w zakresie krzywej obciążenia:

- Oczekuje się, że nowe moce będą potrzebne w Polsce już w roku 1996, pomimo spadku sprzedaży energii elektrycznej w okresie ostatnich kilku lat. W latach 1993-2000 planuje się ponadto wiele prac modernizacyjnych w elektrowniach. Obcinanie szczytów, przesuwanie obciążeń oraz tworzenie elastycznych krzywych obciążenia może zapobiec lub odsunąć w czasie konieczność dodawania nowych mocy i przeprowadzania modernizacji.

- Około 99,5% energii elektrycznej w Polsce jest produkowane w elektrowniach opalanych węglem kamiennym lub brunatnym. Choć należy wziąć pod uwagę wpływ ograniczenia zużycia węgla kamiennego i brunatnego na poziom zatrudnienia w kopalniach, wykorzystywanie tych paliw wiąże się ze znacznymi kosztami środowiskowymi. Oszczędzanie energii pomogłoby zmniejszyć te koszty (jak również spowodować wzrost zatrudnienia netto, jeśli byłoby przeprowadzane poprzez odpowiednio ukształtowany program DSM).

- W kilku kolejnych latach planuje się wprowadzanie nowych mocy przesyłowych w podsystemach przesyłu i rozdziału. Około połowę wartości jednoczesnego szczytu systemowego na poziomie niskiego napięcia można przypisać mocy przesyłowej. Oszczędzanie energii i obcinanie szczytów pomogłoby obniżyć lub odsunąć w czasie konieczność wprowadzania nowych mocy przesyłowych i rozdzielczych.

- Współczynnik obciążenia dla polskiej sieci elektroenergetycznej wynosi obecnie około 65 procent. Wartość ta lokuje się powyżej przeciętnej, co pozwala się spodziewać, że perspektywy zwiększenia współczynnika obciążenia są w

najlepszym razie ograniczone. Korzyści wynikające z większego wykorzystania mocy przesyłowych prawdopodobnie nie zrównoważyłyby ekonomicznych kosztów wypełniania dolin.

Choć ostateczna wartość poszczególnych śródeł po stronie popytu zostanie wykazana w analizie zintegrowanego planowania śródeł, powyższe punkty sugerują, że środkami DSM najbardziej oszczędzające energię elektryczną.

Żrodki zmierzające ku polepszeniu efektywności finalnego wykorzystania energii elektrycznej i ku lepszemu sterowaniu obciążeniem w szczycie będą się różnić w zależności od kategorii odbiorców i rodzaju finalnego zużycia energii elektrycznej. Poszukiwania odpowiednich środków koncentrowały się na następujących kategoriach odbiorców i rodzajach finalnego zużycia energii:

- *Gospodarstwa domowe:* oświetlenie, chłodzenie w lodówkach i ogrzewanie wody. Te rodzaje finalnego zużycia energii stanowią około 79 procent zużycia energii elektrycznej w gospodarstwach domowych lub 22 procent całkowitego zużycia.

- *Lokale niemieszkalne:* oświetlenie. Ten rodzaj finalnego zużycia energii stanowi 60 procent zużycia energii elektrycznej w lokalach niemieszkalnych lub 6 procent całkowitego zużycia.

- *Przemysł:* oświetlenie i silniki elektryczne, choć niektóre środki będą dotyczyć ogólnego zużycia energii elektrycznej w przemyśle. Samo oświetlenie i silniki elektryczne stanowią 80 procent zapotrzebowania w przemyśle lub 42 procent całkowitego zużycia energii elektrycznej.

- *Oświetlenie ulic:* ten rodzaj finalnego zużycia energii elektrycznej stanowi około 1 procent całkowitego zużycia.

W ten sposób ocena obejmuje środki skierowane na rodzaje finalnego zużycia energii elektrycznej stanowiące około 64 procent całkowitego zużycia.

Schemat S-3 przedstawia roczne zużycie energii elektrycznej oraz całkowitą zainstalowaną moc urządzeń w każdej kategorii finalnego zużycia energii, dla której rozwaóano wprowadzenie środków DSM. Wartości dla niektórych kategorii są niższe niż dla całkowitego zużycia w tych kategoriach ponieważ pewne finalne odbiorniki energii, jak np. bardzo duże silniki, nie zostały uwzględnione w analizie. Informacje na temat kosztów i oszczędności rozważanych środków zostały wykorzystane do obliczenia kosztów zaoszczędzonej energii (wyrównany koszt

przyrostowy środka na kilowatogodzinę zaoszczędzonej energii) i kosztów zaoszczędzonej mocy (wyrównany koszt przyrostowy środka na kilowat zaoszczedzonej mocy w systemach wytwarzania, przesyłu i rozdziału).

Schemat S-3
Zużycie energii elektrycznej oraz zainstalowana moc urządzeń w rozważanych kategoriach finalnego zużycia energii

Kategoria finalnego zużycia energii	Roczne zużycie energii (GWh)	% całej kategorii odbiorców	Całkowita moc zainstalo wanych urządzeń (MW)
Gospodarstwa domowe			
Oświetlenie	14.550	55%	13.250
Lodówki	5.412	21%	3.288
Boilery	1.160	4%	--
Lokale niemieszkalne			
Oświetlenie[1]	5.321	54%	2.163
Przemysł			
Silniki[2]	29.771	58%	11.173
Oświetlenie[3]	4.507	9%	1.132

[1] Nie obejmuje 540 GWh zużycia związanego z oświetleniem specjalnym, dla którego nie rozważano środków.
[2] Nie obejmuje 5.971 GWh zużycia i 1,440 MW mocy bardzo dużych silników (przeciętna wielkość 1.200 kW), dla których nie rozważano środków
[3] Nie obejmuje 598 GWh zużycia związanego z oświetleniem specjalnym, dla którego nie rozważano środków.

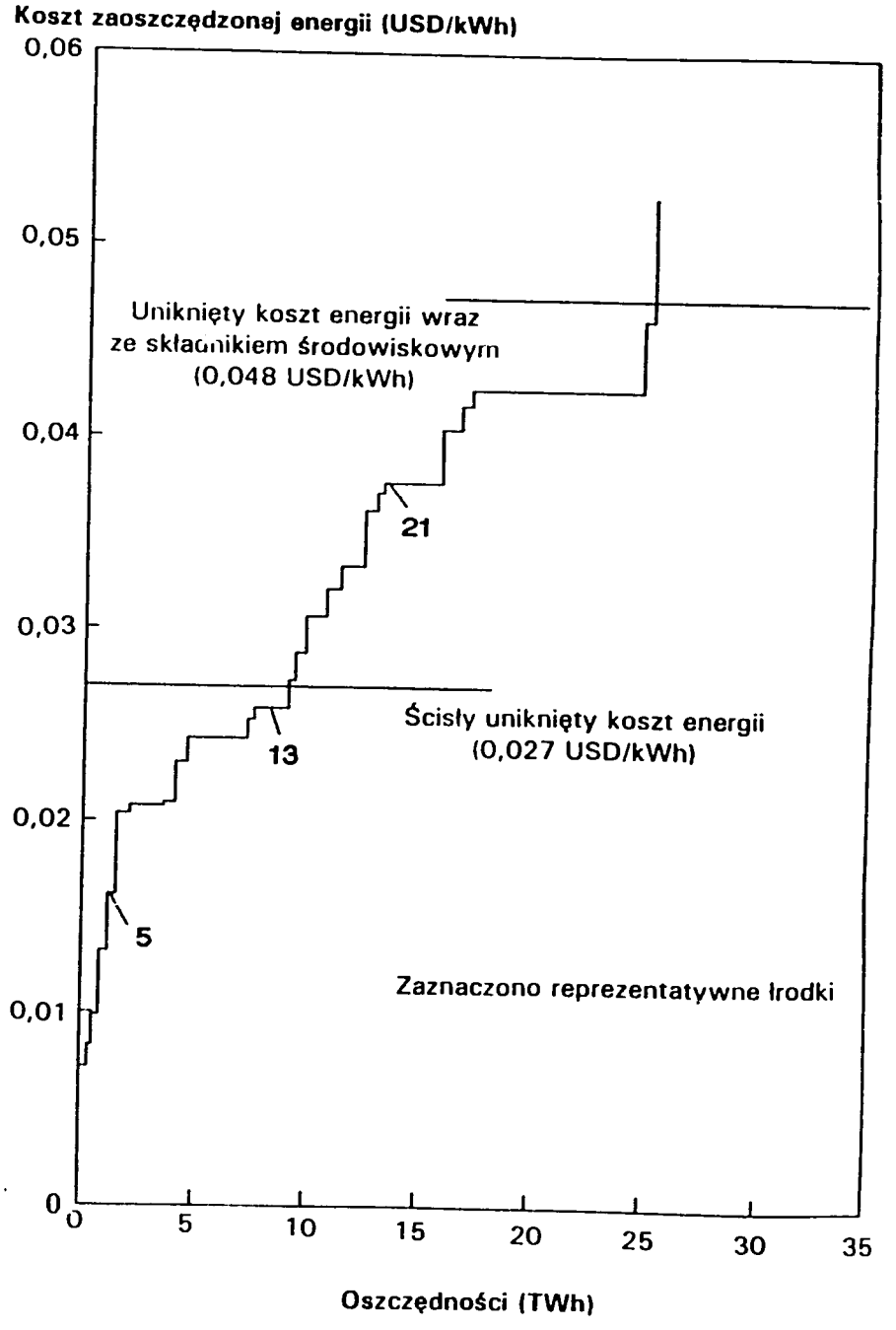
Środki o koszcie zaoszczędzonej energii niższym niż uniknięty koszt energii (łącznie z kosztami środowiskowymi) zostały wypisane w formie listy wraz z potencjalnymi oszczęnościami w kolejności rosnących kosztów dając krzywą oszczędności energii. Po dokonaniu analizy wyciągnięto wniosek, że wszystkie środki, które pomyślnie przeszły przez test kosztu zaoszczędzonej mocy, zdały również test oparty o koszt zaoszczędzonej energii. Dlatego przedstawiona została jedynie krzywa oszczędności energii (por. Schemat S-4).

Z początkowo zidentyfikowanych 58 środków 25 pomyślnie przeszło przez wstępną analizę. Jeśli wszystkie owe środki zostałyby wdrożone u wszystkich kwalifikujących się odbiorców lub wszystkich kategoriach finalnego zużycia energii elektrycznej, suma zaoszczędzonej energii

Schemat S-4: Krzywa oszczędności energii dla Polski

	Środek	Koszt zaoszczędzonej energii	Oszczędności
1	Wymiana często używanych silników o mocy 17,5 kW na silniki oszczędne po przezwojeniu	0,007 USD/kWh	336 GWh
2	Wymiana często używanych silników o mocy 120 kW na silniki oszczędne po przezwojeniu	0,008 USD/kWh	170 GWh
3	Wymiana często uzywanych silników o mocy 3,5 kW na silniki oszczędne po przezwojeniu	0,010 USD/kWh	257 GWh
4	Zastąpienie często używanych silników o mocy 120 kW napędami o regulowanej prędkości	0,013 USD/kWh	368 GWh
5	Wymiana mało używanych silników o mocy 120 kW na silniki oszczędne po przezwojeniu	0,016 USD/kWh	350 GWh
6	Wymiana małych lodówek (ok. 150 l) po ich zużyciu na przeciętny standard USA z roku 1990	0,020 USD/kWh	557 GWh
7	Wymiana dużych lodówek (ok. 230 l) po ich zużyciu na przeciętny standard USA z roku 1990	0,021 USD/kWh	1.496 GWh
8	Wymiana mało używanych silników o mocy 17,5 kW na silniki oszczędne po przezwojeniu	0,021 USD/kWh	518 GWh
9	Zastąpienie często używanych silników o mocy 17,5 kW napędami o regulowanej prędkości	0,023 USD/kWh	537 GWh
10	Owinięcie boilerów do wody	0,024 USD/kWh	116 GWh
11	Konserwacja sprzętu w przemyśle	0,024 USD/kWh	2.552 GWh
12	Zastąpienie ulicznych lamp rtęciowych wysokociśnieniowymi lampami sodowymi	0,025 USD/kWh	314 GWh
13	Optymalizacja procesów produkcyjnych poprzez ich monitorowanie	0,026 USD/kWh	1.531 GWh
14	Zastąpienie lamp rtęciowych w przemyśle wysokociśnieniowymi lampami sodowymi	0,027 USD/kWh	299 GWh
15	Wymiana mało używanych silników o mocy 3,5 kW na silniki oszczędne po przezwojeniu	0,029 USD/kWh	441 GWh
16	Zastąpienie często używanych żarówek w lokalach niemieszkalnych kompaktowymi lampami jarzeniowymi	0,031 USD/kWh	924 GWh
17	Zastąpienie mało używanych silników o mocy 120 kW napędami o regulowanej predkości	0,032 USD/kWh	605 GWh
18	Zastąpienie mało używanych żarówek w lokalach niemieszkalnych kompaktowymi lampami jarzeniowymi	0,033 USD/kWh	1.037 GWh
19	Wymiana często używanych lamp fluorescencyjnych i stabilizatorów w lokalach niemieszkalnych na systemy T-8 po zużyciu	0,036 USD/kWh	532 GWh
20	Zmniejszenie mocy silników	0,037 USD/kWh	271 GWh
21	Zastąpienie często używanych żarówek w gospodarstwach domowych kompaktowymi lampami jarzeniowymi	0,038 USD/kWh	2.850 GWh
22	Wymiana często używanych lamp fluorescencyjnych i stabilizatorów w przemyśle na systemy T-8 po zużyciu	0,040 USD/kWh	888 GWh
23	Czujniki obecności	0,042 USD/kWh	440 GWh
24	Zastąpienie mało używanych żarówek w gospodarstwach domowychych kompaktowymi lampami jarzeniowymi po ich zużyciu	0,043 USD/kWh	7.632 GWh
25	Zastąpienie żarówek o dużej mocy w przemyśle halogenkami metalu	0,046 USD/kWh	378 GWh
		Razem	25.400 GWh

Programy stawek dla przemysłu nie zostały włączone do powyższej analizy klasyfikacyjnej



wynosiłaby 25.400 GWh rocznie, czyli 26,4% energii elektrycznej sprzedanej w kraju w roku 1991. Powyższa wartość określana jest jako ekonomiczny potencjał DSM, którego nie uważa się za realistyczną ocenę, ponieważ opiera się ona wyłącznie na kosztach technologicznych i zakłada 100-procentowe wdrożenie środków DSM we wszystkich kwalifikujących się kategoriach finalnego zużycia. Dlatego oblicza się bardziej realistyczny potencjał DSM uwzględniający koszty programów DSM oraz prawdopodobne poziomy penetracji rynkowej odpowiednich środków DSM. Przykładowo, realistycznie osiągalny potencjał programów DSM, jakie mogłyby zostać wdrożone w Polsce do roku 2000 szacuje się na 1.738 GWh rocznie.

KORZYŚCI I KOSZTY PROGRAMÓW DSM

Środki DSM nie zainstalują się same u odbiorcy; ich ekonomiczny potencjał nie zostanie zrealizowany jeśli nie podejmie się kroków upowszechniających i wdrażających je. Ocena identyfikuje programy DSM, które byłyby wynikiem połączenia środków z mechanizmami marketingu, dostarczenia do odbiorcy i oceny. Programy przedstawione w niniejszym raporcie są jedynie ilustracją zakresu i korzyści programów, jakie mogłyby zostać przyjęte w Polsce. Szczegółowe określenie programów odpowiednich dla pełnego wdrożenia na wielką skalę w Polsce wymaga dalszych badań.

Ważnym aspektem oceny programów DSM w Polsce jest fakt, że funkcjonowanie i wpływ programów są ograniczone do sześciu lat (lata 1995 - 2000), czyli do stosunkowo krótkiego okresu. Na przykład wiele innych regionalnych ocen DSM obejmowało zwykle okres piętnastu lat. Nacisk na natychmiast widoczne rezultaty programów, a nie długoterminowy potencjał strategiczny, jaki położono w niniejszym raporcie, uwypukla te rozwiązania aktualnie dostępne dla osób planujących system w Polsce, które nadają się do finansowania przez jeden z wielostronnych banków rozwoju. Ponieważ jest to podejście ostrożne, nie dające wszechstronnej oceny długoterminowego potencjału w zakresie DSM w Polsce, łączny potencjalny wpływ DSM w Polsce jest zaniżony. W miarę jak przedsiębiorstwa energetyczne i odbiorcy będą poznawać sposób funkcjonowania i korzyści programów DSM, koszty administracyjne będą spadać a stopień uczestnictwa rosnąć, zwiększając potencjalne znaczenie DSM jako źródła energii elektrycznej w Polsce w przyszłym stuleciu.

Prezentacja każdego z programów DSM obejmuje jego opis, omówienie przyjętych założeń co do stopnia uczestnictwa odbiorców w programie i co do kosztów administracyjnych z nim związanych oraz jego wyliczony wpływ na krzywą obciążenia. Stopnie uczestnictwa zostały obliczone oddzielnie dla każdego z analizowanych programów DSM, dzięki czemu odzwierciedlone zostały specyficzne warunki techniczne, do jakich został dopasowany każdy ze środków DSM. Metodologia analiz obejmowała, po pierwsze, określenie kwalifikującej się populacji uczestników, u których dany środek mógł pod względem tecznicznym być zastosowany

lub odpowiedni. Ilość takich odbiorców określano jako procent całkowitej populacji. Taki szacunek "technicznej wykonalności/odpowiedniości" wahał się od 5 procent całkowitej populacji w przypadku programu obejmującego lodówki w gospodarstwach domowych do 90 procent w przypadku programu związanego z wysokociśnieniowymi lampami sodowymi dla oświetlania w przemyśle. Drugim krokiem w metodologii było oszacowanie ilości odbiorców, którzy faktycznie braliby udział w danym programie przez okres sześciu lat analizy. Taki szacunek "penetracji rynkowej" sięgał od 5 procent w przypadku programu zmniejszania mocy silników w przemyśle do 100 procent w przypadku programu związanego z oświetlaniem ulic. W ten sposób otrzymano ostateczny wynik tej metodologii, jakim jest łączna penetracja rynku w roku 2000 obliczona dla każdego programu.

Szacunku kosztów administracyjnych dokonywano na trzech poziomach. W ramach każdego programu DSM każda technologia będzie obarczona pewnymi kosztami administracyjnymi wyliczonymi na jednego odbiorcę lub na jeden środek DSM. Koszty zmienne na poziomie każdego ze środków DSM przyjmują bardzo rozległe wartości w zależności od technologii, typu programu oraz od rodzaju zasobów poświęconych na opracowanie, wdrożenie i ocenę programu. W niniejszym studium te zmienne koszty administracyjne zostały oszacowane dla Polski w oparciu o typ ocenianego programu oraz lokalne koszty robocizny. Koszty administracyjne powstają również na poziomie programu. Związane są one z opracowaniem, upowszechnianiem, kierowaniem, wdrażaniem, śledzeniem i ocenianiem każdego z programów. Te koszty mają często formę stałych kosztów ogólnych, które muszą zostać poniesione, niezależnie od tego czy w programie będzie uczestniczyć 1.000 czy 10.000 odbiorców. Podobnie jak w przypadku kosztów zmiennych, stałe koszty ogólne zostały oszacowane w oparciu o obowiązujące w Polsce stawki za robociznę oraz wielkość i czas trwania poszczególnych programów. Wreszcie, w celu uwzględnienia kosztów administracyjnych ponoszonych przy wprowadzaniu DSM w skali całego kraju, ocena obejmuje również stałe ogólne koszty administracyjne związane ze stworzeniem zespołów ds. DSM w każdym z piętnastu polskich zakładów energetycznych. Każdy zakład energetyczny będzie potrzebować takiego zespołu w celu strategicznego planowania i koordynowania programów DSM we wszystkich kategoriach odbiorców na terenie, który dany zakład obsługuje. Takie koszty ogólne będą powstawać zarówno gdy zakład energetyczny faktycznie będzie realizować programy DSM, jak i gdy nie będzie ich realizować w ogóle, oraz niezależnie od ilości i rozmiaru programów jakie zakład będzie prowadzić.

W niniejszej ocenie analizowane były następujące programy DSM dla Polski:

Gospodarstwa domowe

- oświetlenie
- lodówki
- podgrzewanie wody

Lokale niemieszkalne

- oświetlenie

Przemysł

- silniki
- napędy (napędy o regulowanej prędkości i urządzenia wykorzystujące napędy)
- zmniejszanie mocy silników
- optymalizacja procesów przemysłowych
- oświetlenie
- innowacyjne stawki

Sektor publiczny

- oświetlenie ulic

W Schemacie S-5 zebrano koszty i korzyści związane z powyższymi programami. Pokazuje on również ogólnokrajowe koszty administracyjne.

Schemat S-5
Podsumowanie ogólnokrajowego programu DSM

	1995	1996	1997	1998	1999	2000
Koszty kapitałowe (tys USD)*	9.445	15.287	29.426	37.960	46.930	47.043
Koszty administracyjne (tys USD)	6.984	6.579	10.363	11.975	12.672	9.819
Zaoszczędzona energia (GWh)	117	317	685	1.088	1.489	1.738
Obniżenie zapotrzebowania szczytowego (MW)	32	92	193	314	447	554

* Koszty kapitałowe poniesione przez uczestników z roku bieżącego oraz koszty eksploatacyjne poniesione przez uczestników z roku bieżącego i poprzedniego. Koszty oświetlenia są uśrednione.

Ocena podsumowuje współczynniki korzyści do kosztów dla każdego programu i planu, jak również korzyści netto, koszt zaoszczędzonej energii oraz koszt zaoszczędzonej mocy. Rezultaty te wykazują, że wszystkie programy i plany znajdują uzasadnienie ekonomiczne nawet przy kosztach środowiskowych równych zero. Współczynnik korzyści do kosztów DSM w Polsce mógłby zostać znacznie zaniżony, jeśli z analizy korzyści i kosztów wyłączono by środowiskowe korzyści DSM. Dotyczy to w szczególności Polski, gdzie produkcja energii elektrycznej jest prawie w całości oparta na węglu, którego znaczna część zawiera dużo siarki - szczególnie niebezpiecznej dla środowiska i zdrowia człowieka.

W wielu krajach, w szczególności w Niemczech i Stanach Zjednoczonych, próbuje się ująć środowiskowe zewnętrzne korzyści i koszty produkcji energii elektrycznej poprzez przypisanie im wielkości liczbowych i formalne włączenie ich w proces pozyskiwania źródeł. Banki wielostronne zaczynają uwzględniać koszty środowiskowe w ocenie nowych przedsięwzięć, by spełnić wymogi oceny środowiskowej.

Niektóre metody używane do przypisania wielkości liczbowych zewnętrznym kosztom środowiskowym są oparte na koszcie urządzeń, jakie byłyby wymagane do ochrony środowiska przed zanieczyszczeniem. Inne podejścia polegają na próbach ujęcia w liczby kosztów negatywnego wpływu na środowisko w kategoriach szkód wyrządzonych środowisku i zdrowiu człowieka a kosztów społecznych w kategoriach kosztów przywrócenia środowiska do naturalnego stanu i/lub kosztów utraconej produktywności i zdrowia. W obydwu przypadkach zewnętrzne koszty środowiskowe oszacowywane obecnie są wartościami o charakterze ogólnym i nie są bezpośrednio powiązane ze specyfiką konkretnej sytuacji geograficznej.

W niniejszym studium rozważano trzy oszacowania kosztów środowiskowych. W pierwszym, nie stosującym żadnego wartościowania, dolną granicę zakresu wartości ustalono na zero. Pozostałe dwa, jedno opracowane w Niemczech a drugie w Stanach Zjednoczonych, są oparte na koszcie urządzeń ochrony środowiska ograniczających emisje zanieczyszczeń z elektrowni. Te oszacowania są szczególnie adekwatne, gdyż znaczna część pożyczek potrzebnych dla sektora elektroenergetycznego w Polsce została przeznaczona na urządzenia ochrony środowiska konieczne dla sprostania przepisom w tym zakresie. Oszacowania te połączono z danymi na temat emisji zanieczyszczeń w Polsce w roku 1990 uzyskując szacunkowy zewnętrzny koszt środowiskowy w Polsce wyrażony w USD/kWh. Oszacowanie niemieckie określiło punkt maksymalny na poziomie 0,042 USD/kWh. Oszacowanie amerykańskie określiło połowę zakresu na poziomie 0,021 USD/kWh i ta wartość była używana w niniejszym studium do obliczenia kosztów środowiskowych jakich można uniknąć przez wprowadzenie DSM.

Koszty środowiskowe zostały wykorzystane dwukrotnie w analizie. Najpierw zostały one dodane do unikniętych kosztów energii na etapie wstępnej klasyfikacji środków. Taka "zgrubna" klasyfikacja pozwala na rozważenie większej ilości środków w analizie korzyści i kosztów

programów DSM. Żaden ze środków, które zostały wstępnie zakwalifikowane, nie został jednak później odrzucony w analizie korzyści i kosztów. Następnie koszty środowiskowe zostały wzięte pod uwagę w teście korzyści i kosztów społecznych. Wyniki zostały również przedstawione dla testu całkowitych kosztów źródła, co oznacza, że korzyści i koszty programów DSM mogą być rozważane zarówno z kosztami środowiskowymi, jak i bez nich.

Współczynnik korzyści do kosztów całego planu wynosi 1,87 bez kosztów środowiskowych i 2,66 z kosztami środowiskowymi. Choć niektóre programy mają współczynniki korzyści do kosztów większe niż 5, większość lokuje się w przedziale od 1,1 do 3,0 przy kosztach środowiskowych ustalonych na zero. Wyniki te opierają się na strumieniach korzyści i kosztów, które często wybiegają poza okres trwania programu, gdyż środki techniczne wdrożone dla celów programu dają oszczędności przez cały czas aż do chwili ich wycofania, co zwykle następuje później niż zakończenie programu.

Wartości większości parametrów użytych w niniejszej ocenie zostały przyjęte z dużą dozą pewności. Jeśli nawet nie są one zupełnie ścisłe, to wartości takich parametrów jak np. oszczędności wynikające z użycia danego środka mogły zostać tylko zaniżone, gdyż często opierają się one na wnikliwych badaniach przeprowadzanych w Stanach Zjednoczonych, gdzie różnice w zużyciu energii między urządzeniami standardowymi a wysoce wydajnymi mogą być nie tak duże jak w Polsce. Uniknięte koszty energii i mocy pochodzą ze wstępnych szacunków otrzymanych we wstępnej wersji studium taryfowego. Koszty konwencjonalnych urządzeń i środków technicznych w wielu przypadkach zostały określone na podstawie faktycznych cenników lub ankiet technologicznych.

Natomiast wartości użyte dla kosztów kapitałowych, wpływów na krzywą obciążenia, kosztów środowiskowych, kosztów administracyjnych oraz stopni uczestnictwa w programach są mniej pewne. Przeprowadzono analizę wrażliwości aby określić, czy niepewność co do tych wartości mogłaby negatywnie wpłynąć na ekonomiczne uzasadnienie programów.

Wartości każdego z tych parametrów zostały przedstawione jako rozłożenie prawdopodobieństwa, a wynikające z tego rozłożenie współczynników korzyści do kosztów zostało obliczone metodą symulacji Monte Carlo. W przypadku kosztów administracyjnych założono, że faktyczne koszty będą wynosić 90 procent do 140 procent kosztów bazowych z 70 procent pewności, a 80 procent do 200 procent kosztów bazowych z 99 procent pewności.

Jeżli chodzi o poziomy uczestnictwa w programach, założono, że faktyczne uczestnictwo będzie wynosić między 70 procent a 110 procent wartości podstawowej z 70 procent pewności oraz między 30 procent a 120 procent wartości podstawowej z 99 procent pewności.

Aby uwzględnić czynnik niepewności co do wpływu programów na krzywą obciążenia oraz co do kosztów kapitałowych programów, założono, że koszty kapitałowe i wpływ na krzywą obciążenia będzie się mieścić między 80 procent a 120 procent odpowiednich wartości podstawowych z 70 procent pewności a między 50 procent a 150 procent odpowiednich wartości podstawowych z 99 procent pewności.

Analiza wrażliwości wykazała, że będące wynikiem rozłożenie współczynników korzyści do kosztów było większe niż 1 dla większości planów i programów. Analiza ta sugeruje, że wyniki oceny są prawdziwe dla szerokiego zakresu wartości parametrów.

WDRAŻANIE DSM JAKO ELEMENTU RESTRUKTURYZACJI SEKTORA ELEKTROENERGETYCZNEGO

Analiza przeprowadzona przy pomocy programu DSManager wykazała efektywność kosztową wybranych programów DSM dla Polski. Co więcej, źródła po stronie popytu stanowią znaczne źródło dla sektora elektroenergetycznego. Ich znaczenie jest zaprezentowane poniżej zarówno w kategoriach fizycznych jak i ekonomicznych.

Schemat S-6 przedstawia podsumowanie oszczędności energii i mocy w Polsce w roku 2000 jakie możliwe byłyby do osiągnięcia po wdrożeniu programów DSM opisanych w rozdziale 4. Osiągalny potencjał oszczędności energii wynosi 1.738 GWh rocznie, co się równa 8 procent przyrostowego zapotrzebowania na energię. Osiągalny potencjał oszczędności mocy wynosi 552 MW, czyli 17 procent przyrostowego zapotrzebowania na moc, co mogłoby zastąpić wszystkie nowe moce planowane do roku 2000 w planie rozwoju. Zakładając przeciętne zużycie własne i straty sieciowe na poziomie 16,3 procent, program DSM odpowiadałby 18-tej co do wielkości elektrowni w Polsce pod względem energii a 14-tej co do wielkości elektrowni pod względem mocy. W Polsce istnieje 55 elektrowni cieplnych pracujących na potrzeby systemu elektroenergetycznego i w sumie około 400 bloków energetycznych.

Ekonomiczne znaczenie programu DSM jest proporcjonalne do jego znaczenia fizycznego. Bieżąca wartość ekonomiczna całkowitego programu przedstawionego w niniejszym raporcie wynosi 159 milionów USD.

Koszty każdego z programów DSM sa zwykle pokrywane przez uczestniczących odbiorców i przedsiębiorstwa energetyczne (odbiorcy nie uczestniczący w programie często płacą pośrednio w wyniku zmian struktury taryf). Pożyczka z wielostronnego banku rozwoju mogłaby zostać wykorzystana na sfinansowanie części kosztów przedsiębiorstwa energetycznego związanych z programem DSM. Podziału kosztów pomiędzy różne strony nie da się dokonać przed

wprowadzeniem przepisów regulacyjnych. Poza tym, niektóre z tych kosztów jedynie zastępują koszty, jakie odbiorcy zapłaciliby za energię elektryczną jeśli nie wzięliby udziału w programie. Z tego względu Schematu S-5 nie należy interpretować jako sugestii co do wysokości pożyczki na DSM lub szczegółowego sposobu wykorzystania funduszy z pożyczki. Schemat ten wyraźnie wykazuje jednak ekonomiczne uzasadnienie zaciągnięcia pożyczki na DSM.

DSM z pewnością ma miejsce wśród opcji rozwoju systemu elektroenergetycznego w Polsce na nadchodzącą dekadę i w okresie późniejszym. Podejmowane obecnie w Polsce działania restrukturyzacyjne w sektorze elektroenergetycznym powinny uwzględnić potencjał źródeł po stronie popytu. Zintegrowane planowanie źródeł określi rolę DSM z większą dokładnością. Do tego czasu należy podjąć dwa działania, które jeszcze bardziej zwiększą perspektywy DSM w Polsce.

Ramy prawne i regulacyjne w jakich funkcjonuje sektor elektroenergetyczny w Polsce powinny zapewnić, by zintegrowane planowanie źródeł było najkorzystniejszym planem dla przedsiębiorstwa energetycznego i planem opartym o najniższe koszty dla jego odbiorców i społeczeństwa jako całości. W ocenie omówione są następujące szerokie zagadnienia, które mogłyby poprzeć wdrożenie zintegrowanego planowania źródeł i DSM:

- cel zintegrowanego planowania źródeł
- opracowanie zintegrowanego planu źródeł
- kompetencje dla Polskich Sieci Elektroenergetycznych S.A. do wdrożenia zintegrowanego planu źródeł
- pokrycie kosztów DSM poniesionych przez zakłady energetyczne w stawkach za energię elektryczną
- możliwość zdobycia przez zakłady energetyczne bodźców finansowych do wdrażania DSM
- uwzględnienie zaangażowania społeczeństwa.

Sformułowanie i wdrożenie ram regulacyjnych stanowi nieodzowną podstawę dla dalszego rozwoju źródeł po stronie popytu. Jeśli ma jednak dojść do powszechnego wdrażania programów DSM, to konieczne jest również zdobycie większej ilości informacji na temat reakcji odbiorców na DSM, szkolenie pracowników polskich przedsiębiorstw energetycznych oraz techniczne poparcie całej koncepcji. Pilotowy program DSM może osiągnąć wszystkie te cele.

Ponieważ przemysł oferuje największy osiągalny potencjał oszczędności oraz najbardziej efektywne kosztowo programy, jest on głównym kandydatem do programu pilotowego. Część 2 niniejszego raportu przedstawia szczegółowo program pilotowy odpowiedni dla wsparcia finansowego ze strony wielostronnych banków rozwoju.

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Schemat S-6
Podsumowanie możliwych do osiągnięcia oszczędności energii i zapotrzebowania w Polsce w roku 2000

PROGRAM	Energia (GWh)	Zapotrzebowanie (MW)	Udział przyrostowej energii (1995-2000)*	Udział przyrostowego zapotrzebowania (1995-2000)**
Oświetlenie w gospodarstwach domowych	267	48	1,2 %	1,5 %
Chłodzenie w gospodarstwach domowych	65	8	0,3 %	0,2 %
Ogrzewanie wody w gospodarstwach domowych	11	2	0,1 %	0,1 %
RAZEM GOSPODARSTWA DOMOWE	**343**	**58**	**1,6 %**	**1,8 %**
Oświetlenie w lokalach niemieszkalnych	225	36,0	1,1 %	1,3 %
RAZEM LOKALE NIEMIESZKALNE	**225**	**36,0**	**1,1 %**	**1,3 %**
Silniki w przemyśle	401	64	1,8 %	2,0 %
Napędy	68	10	0,3 %	0,3 %
Zmniejszanie mocy silników	7	1	0,0 %	0,0 %
Procesy przemysłowe	171	28	0,8 %	0,9 %
Oświetlenie w przemyśle	256	44	1,2 %	1,4 %
Stawki w przemyśle	59	258	0,0 %	7,9 %
RAZEM PRZEMYSŁ	**962**	**405**	**4,4 %**	**12,5 %**
Oświetlenie ulic	208	53	1,0 %	1,6 %
RAZEM SEKTOR PUBLICZNY	**208**	**53**	**1,0 %**	**1,6 %**
RAZEM OSZCZĘDNOŚCI	**1,738**	**554**	**8,1 %**	**17,2 %**

Uwaga: Sumy mogą się nie zgadzać, gdyż zostały zaokrąglone.

* Wzrost przyrostowej energii został obliczony ze Studium Taryfowego Energii Elektrycznej: Polskie Sieci Elektroenergetyczne S.A., Raport Wstępny, Luty 1993.

** W obliczeniach dla celu opracowania modelu wzrost przyrostowego zapotrzebowania w latach 1995 do 2000 został obliczony jako 3.253 MW.

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CHAPTER 1: INTRODUCTION

1.1 PROJECT BACKGROUND AND OBJECTIVES

This report presents the results of work sponsored by the Bureau for Europe of the United States Agency for International Development (USAID). Through a bilateral program, USAID has been providing assistance to the Government of Poland (GOP) under the Eastern Europe Regional Energy Efficiency Project. One of the project's tasks included work on demand-side management in Poland, which is the topic of this report.

Over the past four years, the GOP has begun to introduce sweeping legal and regulatory reforms to accelerate the country's transition to a market-oriented economy. The GOP has recognized the key role of the energy sector in this fundamental transformation, in terms of both its importance to other sectors and its own investment needs.

The GOP initiated the Energy Sector Restructuring, Privatization, and Regulatory Reform Program in 1991. The program was developed in coordination with the World Bank, and involves assistance from several bilateral donors, including USAID. It aims to liberalize energy prices, promote enterprise competition within the energy sector, and transform the ownership, control, and operation of state-owned enterprises in a manner consistent with a market model of the energy sector. These reforms are expected to revitalize the energy sector, enhance its long-term financial viability, and encourage economically optimal investment and consumption decisions.

To encourage the most economically efficient allocation of resources within a free market framework, the Energy Sector Restructuring Program includes a least-cost planning component. True least-cost planning, also known as integrated resource planning (IRP), entails the evaluation of both supply- and demand-side resources to identify the mix of resources that yield the least cost to society. Supply-side resources consist of the conventional generation, transmission, and distribution facilities. Demand-side resources, on the other hand, include measures or programs that modify the timing and level of consumer demand. IRP therefore extends the domain of utility planning and resources beyond the distribution system to the customer side of the meter.

The GOP is coordinating several activities to develop the least-cost plan. A USAID Electricity Transfer Pricing and Retail Tariff Study is underway to formulate an electricity pricing strategy. The formulation of a potential supply-side development plan has begun with assistance from Austrian and French teams.

This study complements those efforts by identifying and assessing potential demand-side resources for Poland. The overall objectives of this project are to:

- identify demand-side management (DSM) programs that should be considered within the context of a least-cost power system plan
- evaluate the costs and benefits of these programs
- assist Polish authorities in developing a lasting institutional capability, within government, the utilities, and the private sector, to design, implement, and evaluate DSM programs on a continuing basis.

The project comprises four components to meet these objectives:

- institutional development assistance to help the GOP formulate and implement a regulatory and legislative framework that will encourage IRP
- a national DSM assessment that identifies potential DSM programs and evaluates the costs and benefits of these programs
- the design of a load research program to generate the data necessary for effective program design (spot end-use and whole-premise load monitoring will be conducted as part of this component to demonstrate the principles of load research and to provide preliminary data for use in the assessment)
- the design of an industrial pilot project, based on discussions with utility staff and consumers.

This two-part report describes the above activities, and the findings and recommendations of the study. Part 1 discusses the national DSM assessment, while Part 2 describes the proposed load research and industrial pilot projects. The assessment focuses on the costs and benefits of DSM programs that can realistically be implemented over the next six years as part of a project suitable for multilateral development bank financing. This emphasis on immediate project possibilities, rather than long-term strategic potential, highlights options currently available to Polish energy planners instead of a comprehensive evaluation of the long-term theoretical potential of DSM.

1.2 DSM IN THE POLISH CONTEXT

The Role of DSM and IRP

Demand-side management (DSM) is the identification, use, and evaluation of demand-side resources. DSM is achieved through ***energy efficiency***, which is the reduction of kilowatt hours (kWh) of energy consumption or ***load management***, which is the reduction of kilowatts (kW) of power demand or the displacement of demand to off-peak times. It encompasses a broad range of measures to encourage consumers to voluntarily modify their electricity consumption without compromising service quality or customer satisfaction. Tariffs can be designed to stimulate a shift in consumption to off-peak periods. End-use energy efficiency can reduce both energy and peak power demand. Direct load control can likewise limit peak power demand.

Demand-side management is typically accomplished through utility sector programs, as the consequence of utility planning for and acquisition of electric resources. In this context, DSM is distinct from other activities that can achieve end-use energy efficiency throughout society. Such activities include the implementation of building codes and appliance efficiency standards by government bodies and the normal market response of consumers to changes in the price of energy and the availability of new end-use technologies.

Demand-side resources should be developed when they are shown to be less costly, from society's point of view, than adding another unit of capacity or generating another unit of energy. For these DSM measures to succeed, however, both utilities and consumers must have incentives to participate in DSM programs. Put another way, the Polish market model of the power sector must ensure that price signals and other incentives are in place to make the least-cost plan (from society's point of view) the most profitable plan for utilities and consumers alike.

It may seem irrational for a utility to try to sell less of its product. This perception reflects the limitations of traditional power sector regulation rather than the value of DSM. Power sector regulations in many countries have not provided utilities with incentives to consider both supply- and demand-side resources when developing a least-cost resource mix. In fact, load-reducing DSM may be an important strategy for providing electric services at least cost, since it is often cheaper to save energy than to produce it. In instances where regulations encourage market choices and socially optimal investments to coincide, utilities have come to understand that the electric resources that exist on the customer's side of the meter may be more cost-effective in meeting electric power needs than building expensive new power

plants. From this experience came the recognition that a "negawatt" of electricity saved through DSM is as good as a megawatt of generation capacity.

For instance, if a utility manages to reduce electricity demand, it can postpone the construction of expensive new power plants or increase reliability. Alternatively, reducing total generation can obviate the installation of costly environmental controls. Capturing these benefits, however, requires utilities to view their roles differently. Whereas utilities that rely solely on conventional supply-side resources such as power plants often view themselves as commodity producers, utilities that tap the potential of DSM must perceive themselves as service providers, i.e., that they are in the business of meeting consumer needs rather than simply producing kilowatt-hours.

Utilities may invest in DSM in several ways. One way is for the utility to issue requests for proposals (RFPs) for new resources. Generation companies may come forward with contracts for firm supplies, while consumers, especially large customers, may offer energy saving opportunities. Frequently, energy service companies identify potential consumer savings and enter into contracts with one or more consumers to obtain those resources. The energy service company may then package several of these contracts into a single proposal to the utility. Once the utility receives the bids, it orders the resources by cost and contracts with those presenting the least costly proposals (both supply- and demand-side) until the utility's needs are fully met.

An alternative (but not mutually exclusive) approach is for the utility to develop a DSM program on its own, and then to implement the program itself or through contractors. Programs may run a gamut from the passive end of the spectrum, in which utilities may only provide additional information to consumers to increase their awareness of the opportunities and benefits of energy efficiency, to the aggressive end, in which utilities may go to customer premises and install more efficient equipment. Rebate programs are in between these extremes. In rebate programs, the actual installation of the measure is left up to the consumer, but an economic incentive is provided by the utility. Although program participation increases with utility promotion and rebate levels, higher rebates and aggressive promotion typically cost more. Part of the art of program design is to balance these costs and benefits.

Just as utilities recover the cost of supply-side resources in their rates, regulations should allow utilities to recover the costs of DSM programs by including these costs in the ratebase. These costs may include the revenues lost by virtue of DSM program participation. Regulations may also require that resource planning take into account environmental costs.

By providing incentives such as these to utilities, regulations can ensure that supply- and demand-side resources are evaluated on an equal basis.

The Energy Sector Restructuring Program provides a unique opportunity for the GOP to establish a regulatory framework that will help ensure that socially optimal investments are made through market mechanisms. ***Without IRP and supporting regulations, the potential economic and environmental benefits of DSM will not be realized, and the aims of the Energy Sector Restructuring Program will not be served.***

IRP is fully compatible with a market model of the power sector. IRP regulations in Poland should not stipulate which utility resources should be used, but rather the rules for resource selection. In fact, IRP broadens the power sector market by defining the market to encompass both supply- and demand-side resources. Regardless of how the power sector market is ultimately structured, entities that purchase power resources can be given a choice of procuring demand-side or supply-side resources. IRP regulations will ensure that the prices they pay and the incentives they are given reflect the GOP's broader economic, social, and environmental considerations. A discussion of the regulatory changes required in Poland to implement IRP is presented in Chapter 5 of this assessment.

Overview of the Polish Power Sector

Poland has nearly 400 power and combined heat and power (CHP) stations with an installed capacity of 29,627 MW. Almost 100 percent of the country's electricity is produced by lignite- and coal-fired steam turbines, with lignite plants contributing 43 percent of total production and hard coal plants providing 57 percent. Of total generation, 15 percent is produced by CHP and collector grid plants.[1] Although Poland has some 2,000 MW of hydroelectric capacity, 1,500 MW of this comprise five pumped storage plants with little net generation. The high-voltage transmission grid consists of 220 kV, 400 kV, and 750 kV lines totaling some 12,300 km.

These facilities are currently operated by 34 generating companies, a national transmission company (Polskei Sieci Elektroenergotyczne, or Polish Power Grid Company, PPGC) and 33 distribution companies. However, the Energy Sector Restructuring Program has proposed that these entities be reorganized as follows:

[1] Collector grid and CHP plants produce both heat and power. CHP plants produce primarily heat, whereas collector grid plants produce primarily power.

- coal-fired power plants will be reorganized into four commercial generating companies
- CHP facilities will be reorganized into nine commercial utilities
- distribution companies will be reorganized into 10 to 20 regional companies.

PPGC has already been reorganized as a joint stock company, currently owned by the National Treasury. It will retain its role as the single national transmission company. Currently, it is also responsible for system planning, dispatch, and control, bulk power purchases and sales, and retail tariff recommendations. It is expected that a regulatory agency will be established as part of the energy law now being prepared. This agency will supervise the operation of the power market.

The transition of the Polish economy has been characterized by a nearly 12 percent decline in gross domestic product (GDP) between 1989 and 1990, and a 7 percent decline between 1990 and 1991. Industry has accounted for most of this fall. Power statistics reflect this economic slowdown. Annual peak system demand fell from 24,267 MW in 1989 to 22,602 MW in 1990, and increased slightly to 22,682 in 1991. Peak demand occurs in the winter on a seasonal basis, and in the evenings on a diurnal basis.

The domestic production of electricity has fallen from 147,343 GWh in 1989 to 135,388 GWh in 1990 and 132,077 in 1991. Domestic sales in 1991 totaled 96,384 GWh, of which 53.0 percent was consumed by industry,[2] 10.2 percent by the commercial sector, 21.6 percent by dwellings, 8.7 percent by farms, 5.1 percent by national and municipal railways, and 1.4 percent by street lighting.

Because of the recent decline in electric sales, new generation capacity is not required immediately. As noted in the Tariff Study,[3] 120 MW combustion turbines are expected to be added in 1996, 1997, and 2000. A lignite-fired thermal plant could be added in 2003. Numerous plants are candidates for repowering, and environmental controls will probably be

[2] Because consumption figures are compiled by tariff class, and tariff classes are defined primarily by voltage level, the "industrial" class in fact consists of both high- and medium-voltage consumers. Some of these customers may not be typically considered industrial, e.g., large hotels. Similarly, "commercial" consumption includes some low-voltage light industry.

[3] *Electric Power Tariff Study: Polish Power Grid Company* (draft report), RCG/Hagler Bailly, Inc. for USAID, 1993.

retrofitted to most plants; it is expected that between 1992 and 2000, a total of 2,865 MW of capacity will undergo some form of rehabilitation at a cost of US $800/kW. Although the Supply Plan Study being prepared with the assistance of the Austrian team will provide a more accurate assessment of these costs, it can be assumed at this time that half of these costs will be associated with environmental controls. Extensive transmission and distribution investments are also expected in the 1995 to 2000 time frame.

DSM Issues in Poland

During the course of this study, GOP and PPGC staff raised several issues related to the applicability of DSM in Poland. Four of these issues are addressed in this section.

DSM and Declining Electricity Demand. The issue most commonly raised was whether DSM was appropriate for Poland in light of the fall in electricity demand over the past few years. Given a 1992 peak system load of approximately 22,000 MW, the system currently has a nominal reserve margin of about 35 percent. In addition, as much as 1,290 MW are available as surplus power from auto-producers, bringing the nominal reserve margin to over 40 percent. However, eliminating non-firm resources such as auto-producers and taking into account plant deratings bring the total firm reserve margin down to about 27.5 percent.

The Tariff Study adopted a 20 percent planning reserve margin, which is not much less than the current total firm reserve margin. Based on the preliminary load forecast and generation expansion plan referenced in the Tariff Study, it is expected that capacity additions will be required as early as 1996. Moreover, the extensive rehabilitation of existing capacity is envisioned during the 1993-2000 time frame. Because DSM can be considered an alternative to these capacity additions and rehabilitation, identifying and assessing demand-side resources at this time is appropriate.

Even if current reserve margins were higher and capacity additions and rehabilitation were expected only in the distant future, several arguments would remain in favor of DSM:

- The fundamental institutional changes to be brought about by the Energy Sector Restructuring Program present a unique opportunity to develop a lasting framework for optimal power system planning and operation. It is critical to establish a regulatory framework that takes into account all resource options. Conducting this

study within this framework will help determine whether DSM has a place among Poland's near-term resource options.

- Load will eventually increase and generation units will be retired to the point that further capacity is needed. Because there is uncertainty about when this will happen, experience with DSM should be developed now so that effective responses will be available when needed.

- If true IRP is implemented in Poland, environmental costs will weigh heavily against coal-based generation, which accounts for the vast majority of electricity generation. DSM offers immediate environmental benefits in this regard.

- Avoided capacity is only one monetary benefit of DSM. By adopting DSM, both utilities and consumers will forego energy costs that would have been incurred otherwise. Energy intensity in Poland is two to three times higher per unit of GDP than in European OECD countries. Clearly, there is considerable scope and justification for DSM programs, which emphasize energy efficiency.

DSM and Increased Social Costs. Another, far more politically important issue also emerged. Virtually all electricity in Poland is produced from coal- or lignite-fired plants. Coal mining has been hit hard by the economic transformation in Poland, both as a result of the removal of production subsidies and lowered demand. Many mines have been closed, others face closure, and unemployment in mining regions is at record levels. At the end of September 1992, 70 coal mines were operating in Poland. Ten mines are slated for closure in 1993, twelve in 1994, and so on, until by the end of the year 2000, only 25 mines are planned to be operating. Many mines have cut their workforces by one-third or more since 1990. Employment is expected to fall from a current level of 310,000 to 225,000 by 2010. The cost of mine closures, including lost jobs, lost production, and mine shut-downs, is estimated at $250 million in 1993 alone.

Why, then, should DSM be considered a resource option when it may only accelerate mine closures and raise the associated social costs? Every resource has its costs. One aim of IRP is to determine which costs and benefits are counted when evaluating options, and to apply these cost accounting principles consistently across all potential resources. While formulating power sector regulations, the GOP may wish to take environmental and other externality costs into account in addition to direct monetary costs.

There is already an extensive body of literature on the environmental costs of various utility resources. This study will consider those costs when assessing the benefits and costs of DSM programs. Although it does not address the social costs of DSM, these costs could be addressed in the course of the IRP analysis. Some studies have been conducted in the United States on the employment impacts of DSM. They have found that DSM is a net producer of employment.[4] If the same holds for Poland, the attractiveness of DSM would be enhanced. In any case, the social costs associated with a resource should not automatically disqualify that resource from further consideration; rather, they should be considered within the broader IRP framework.

Equity Concerns and DSM Programs. The costs of DSM programs would be absorbed in rates, just as the costs of supply-side resources are. While program participants would have their bills reduced by virtue of the load reducing measures they adopt, non-participants could face higher bills. Some utility staff have pointed out that one sector or group of consumers could end up paying more so that another sector or group can pay less, resulting in a potentially indefensible cross-subsidy.

DSM programs should be adopted only if they are shown to be economically justified (and this report aims to determine whether selected programs are). If they are, then participation should certainly be encouraged. If participants and non-participants were treated equally, there would be little incentive for voluntary DSM program participation. The real issue, then, is not that participants enjoy an advantage over non-participants, but that all consumers have opportunities to participate. Programs should therefore be developed for all customer classes so that the benefits of participation can be distributed equitably. Consequently, this report considers programs directed towards a broad range of consumers, including industry, commercial enterprises, and households. Cost tests, which are described in the following section, can be used to determine the financial impacts of programs on both participants and non-participants, and financial incentives can be adjusted accordingly to ensure that each participant group receives appropriate benefits.

Consumers will voluntarily participate in DSM programs if they feel it is in their best interest to do so. Bill impacts are often a major consideration when consumers decide whether or not to participate. However, the current billing system in Poland, at least for households and small commercial users, does not provide the immediate price signals that can influence

[4] Geller, H. et al., *Energy Efficiency and Job Creation*, American Council for an Energy-Efficient Economy, 1992.

consumer behavior. Because meters for small consumers are generally located inside the customer's premise, they cannot be read each month; nor can accounts be settled on a monthly basis. In fact, it is not uncommon for meters to be read only once in two years. This denies the consumer the information necessary to make good energy management decisions, and impedes the functioning of a robust power market.

DSM and the Current Economic Environment. Finally, several Polish counterparts pointed out the instability of the current economic environment in Poland. The only thing which is certain is that further change is inevitable; what good then is a DSM assessment when demand patterns are undergoing continuous and rapid change? There are several responses to this observation:

- Uncertainty about the future is not unique to Poland; it is common to all planning efforts. This uncertainty is one reason why planning is called for. Under the circumstances, planning may not be perfect, but it is better than the alternatives. The planning process should help identify those factors which have the greatest influence on outcomes and should develop strategies for minimizing the risk associated within the uncertainty surrounding these factors. This report includes sensitivity analysis and probabilistic simulation to explicitly address this uncertainty.

- DSM program participation and impacts should be modeled to generate insights and not numbers. The results of this analysis should not be interpreted narrowly (e.g., the benefit/cost ratio of a particular program is 3.5). Rather, they should be viewed in terms of whether DSM programs remain attractive under a wide range of conditions that could prevail in the future.

- Because of low capacity utilization, the results of this DSM assessment are conservative. Industry likely holds the greatest DSM potential, and as economic activity and capacity utilization increase, the benefits of DSM will likewise increase because more energy will be saved for a given measure. For example, the benefits of replacing a standard motor with a high-efficiency motor are far greater in a two-shift factory than in a one-shift factory.

- Similarly, the assessment takes a conservative view towards participation. All sectors in the economy face enormous pressures just to survive the country's economic transformation, and as pointed out in the Tariff Study, electricity costs are a relatively small share of most entities' total budget. Therefore, we assume in this assessment

that consumer preoccupation with other pressing issues reduces participation from levels that would be expected under more stable circumstances.

Notwithstanding the above, the uncertainty of industrial facility survival is a problem. In the highly unstable economic environment of Poland, a large number of industrial and commercial facilities are being closed, many of them permanently. This situation creates a difficult challenge to the successful implementation of DSM programs in which special precautions have to be taken to avoid a high rate of loss or non-performance of utility DSM investments.

1.3 SCOPE OF THE DSM ASSESSMENT

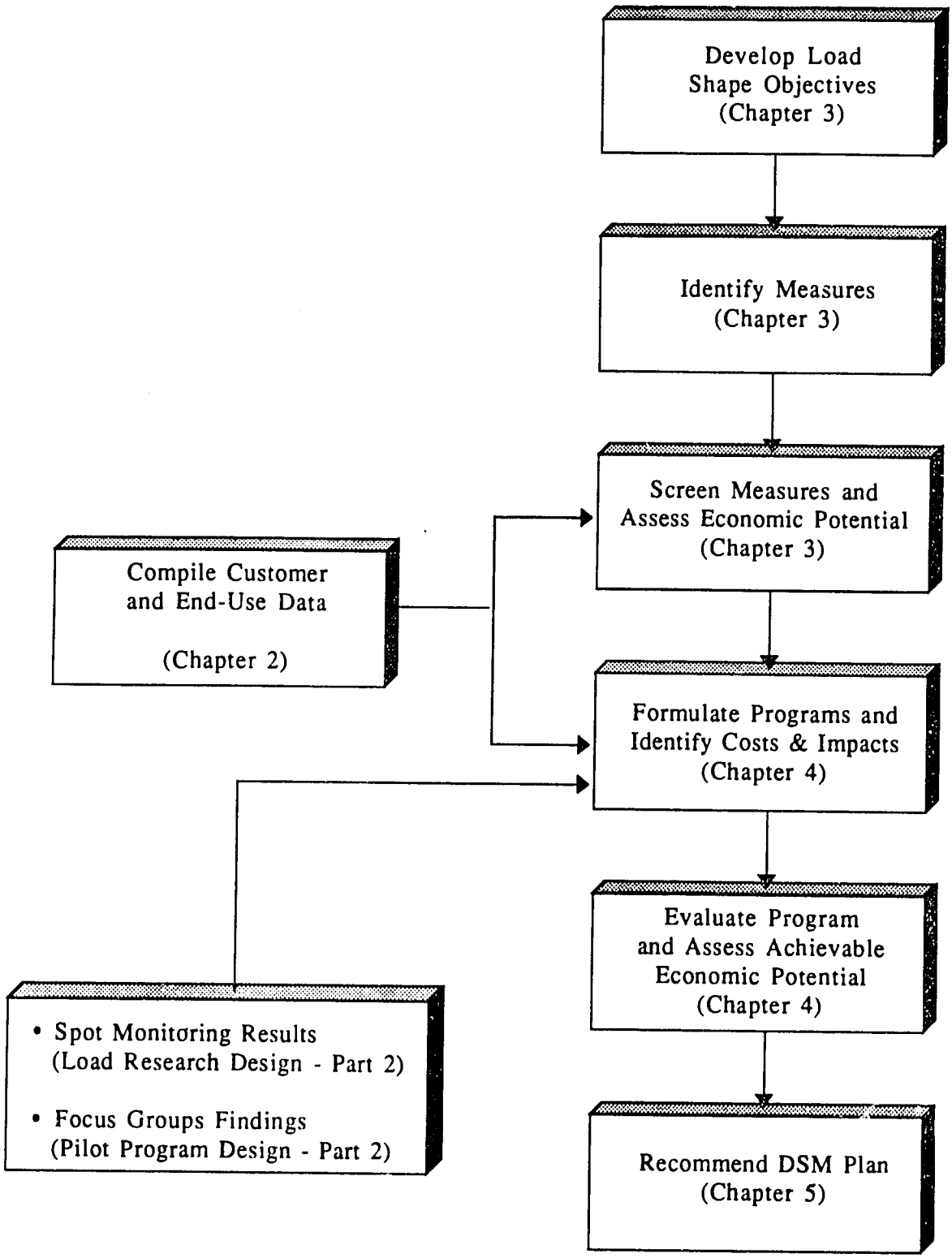
DSM will find a place in Poland's least-cost plan only if it is shown to be ***economically justified*** from a social perspective as well as ***financially viable*** for both utilities and consumers. However, financial viability will depend upon the power sector regulations and revised tariffs, which are still being prepared. Since programs cannot be designed (e.g., with respect to rebate levels) to meet utility and consumer criteria until these regulations and tariffs are in place, this assessment focuses only on the economic justification for DSM.

In any case, the economic analysis of DSM is the first step towards developing a DSM program. If DSM cannot be shown to be economically justified, then subsequent financial analysis is not warranted. If DSM programs are shown to be economically justified, then this analysis can serve as the foundation for subsequent financial analysis, program refinement, and the formulation of regulations that will make economically justified programs financially viable.

Moreover, this economic analysis is required if DSM is to be considered for multilateral development bank (MDB) financing. While MDBs would also require financial analysis for the appraisal of a full-scale implementation project, it is expected that economic analysis alone will be sufficient for the appraisal of a pilot project. The financial dimensions of the pilot project would be addressed once the new energy sector regulations and tariffs are in place, probably after the loan is appraised. This report has therefore been prepared with the analytical rigor necessary to support the loan appraisal process.

Exhibit 1 illustrates the scope of this analysis. As noted above, DSM redefines the boundaries of utility planning to include the customer. Chapter 2 of this report characterizes electricity consumption in Poland at both the customer and the end-use levels. The Institute of Power Engineering in Katowice has provided customer class load shapes, while the Polish

Exhibit 1. Elements of the DSM Assessment



Foundation for Energy Efficiency has provided information on the types of end-use technologies currently in use and the number of installations.

Chapter 3 opens with a discussion of the load shape objectives for DSM in Poland. Just as expected changes in load shapes can guide the selection of new supply options (e.g., whether a peaking or baseload unit is called for), DSM programs can be designed to achieve particular load shape objectives. These objectives are summarized in Exhibit 2. Given that capacity additions are expected in Poland as early as 1996, and that there may be relatively high environmental costs associated with conventional coal-fired generation, this study examines potential DSM programs for conservation and peak-clipping.

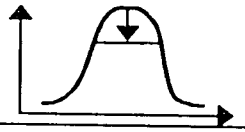
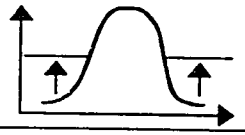
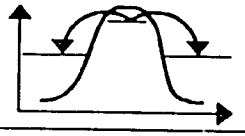
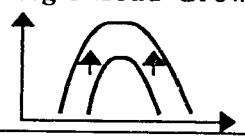
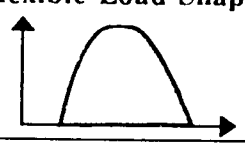
Numerous measures are available in all sectors to achieve these objectives. Chapter 3 also identifies industrial, commercial, and residential measures that are suitable for Poland. In order to screen out less promising measures, the cost of conserved energy is calculated for each measure and compared to the avoided energy cost. This screening is carried out using the technology and end-use data described in Chapter 2. These measures are ordered by cost to provide an energy efficiency supply curve. Only measures with a cost of conserved energy less than avoided generation cost are retained for further consideration. The total energy savings associated with the cost-effective measures is referred to as the "economic potential" of the measures.

Measures must be packaged with marketing, delivery, and evaluation mechanisms in order to become actual demand-side resources. Without marketing and delivery, measures would never be installed; without evaluation, the contribution of the resource to power sector needs cannot be determined. These packages constitute DSM programs. Chapter 4 describes how these measures can be developed into programs, the costs of doing so, and the expected participation and load impacts of the resulting programs.

The information needed for this is drawn from data presented in Chapter 2 as well as the findings of the focus groups conducted as part of the pilot program design and the spot load monitoring carried out as part of the load research design. These activities are described in further detail in Part 2 of this report. Economic benefit/cost ratios are then calculated for each program. The load impact of those programs that are economically justified is referred to as the "achievable potential," which takes into account the gradual growth of program penetration.

Chapter 5 presents a recommended national DSM plan. This plan is a realistic assessment of the cost-effective demand-side resources that could be implemented in Poland to meet consumer needs at least cost in a near-term DSM project. The chapter also presents an

Exhibit 2. The Effects of DSM on Load Shape

Effect on Load Shape	Description	Means of Implementation
Peak Clipping 	**Peak clipping** refers to the reduction of utility loads during peak demand periods. This can defer the need for additional generation capacity. The net effect is a reduction in both peak demand and total energy consumption.	Direct utility control of consumer appliances or end-use equipment. Time-of-use rates may also accomplish peak clipping.
Valley Filling 	**Valley filling** entails building off-peak loads. This may be particularly desirable when the long-run incremental cost is less than the average price of electricity. This is often the case when there is underutilized capacity that can operate on low-cost fuels. The net effect is an increase in total energy consumption, but no increase in peak demand.	Creation of new off-peak electric loads that previously operated on non-electric fuels, such as overnight charging of electric cars and thermal energy storage.
Load Shifting 	**Load shifting** involves shifting load from on-peak to off-peak periods. The net effect is a decrease in peak demand, but no change in total energy consumption.	Time-of-use rates and/or the use of storage devices that shift the timing of conventional electric appliance operation.
Strategic Conservation	**Strategic conservation** refers to reduction in end-use consumption. There are net reductions in both peak demand (depending on coincidence factor) and total energy consumption.	End-use efficiency.
Strategic Load Growth 	**Strategic load growth** consists of an increase in overall sales. The net effect is an increase in both peak demand and total energy consumption.	Increased energy intensity and/or the addition of new customers.
Flexible Load Shape 	**Flexible load shape** refers to variations in reliability or quality of service. Instead of influencing load shape on a permanent basis, the utility has the option to interrupt loads when necessary. There may be a net reduction in peak demand and little if any change in total energy consumption.	Interruptible and curtailable rates.

economic analysis of the entire plan in terms that could be used to support the appraisal of the DSM component of an MDB loan to Poland. Chapter 5 concludes with an overview of the next steps required to further develop demand-side resources in Poland: the design and implementation of a DSM pilot project and the formulation of a supportive regulatory framework.

A key element of this analysis is the use of DSManager to carry out the economic benefit/cost assessment. The Electric Power Research Institute (EPRI) sponsored the development of DSManager to provide a tool for utilities to use in assessing in detail the costs and benefits of DSM programs to society, customers, and the utility itself. It is broadly recognized as a leading DSM program assessment tool, and has been used by over 100 utilities and regulatory commissions in the United States and Canada.

DSManager can evaluate DSM programs from five different standpoints:

(a) The *Participant Test* measures the financial costs and benefits to program participants.

(b) The *Ratepayer Impact Test* measures program impacts on retail tariffs and hence customer bills due to changes in utility revenues and operating costs caused by the program. This test assumes that utility expenses, revenue losses, and avoided cost savings resulting from the programs are passed on to ratepayers; no other costs or benefits are included. The test includes both participants and non-participants as customers.

(c) The *Utility Cost Test* measures the costs and benefits of a DSM program as a resource option based on the costs incurred by the utility, including incentive costs, and excluding net costs incurred by the participant.

(d) The *Total Resource Cost* (TRC) Test measures the costs and benefits of a DSM program as resource option within the extended power system (i.e., including the customer side of the meter) based on the total costs and impacts of the program, including both the participants' and the utility's costs.

(e) The *Societal Cost Test* is a variant of the TRC test in that it includes externalities (e.g., avoided environmental costs) and excludes tax credit benefits. Whereas the TRC examines the costs and benefits of resources as they accrue only within the power system, the Societal Cost Test accounts for the costs and benefits of resources as they accrue to the economy as a whole.

Exhibit 3 depicts the scope of these tests. For each test, the relevant perspective is shown (i.e, that of participants, non-participants, the utility, and the economy) as well as a simplified representation of the components of benefit and cost that define the tests. Tests (a), (b), and (c) are financial analyses from the perspectives of DSM program participants, all ratepayers, and the utility, respectively. Test (d), the TRC Test, reflects the definition of utility planning which includes the customer's side of the meter. Finally, test (e), the Societal Cost Test, assesses the program costs and benefits at a national level by taking into account environmental and other social costs.

In terms of MDB loan appraisal, tests (a), (b), and (c) represent financial analyses. They can help determine the financial viability of the program to each relevant entity. The TRC Test is typically not of concern to MDB loan appraisal (although if taxes and tax credits are not considered, it can serve, as in this report, as an economic analysis that does not include environmental costs). On the other hand, test (e), the Societal Cost Test, represents an economic analysis that MDBs rely on to determine whether a program or investment is justified from a national perspective. For the purposes of MDB loan appraisal, the costs and prices used in this test should be based on shadow prices rather than market prices.[5] The Societal Test is also useful in that it can take into account environmental and other social costs; MDBs now typically incorporate environmental impact assessment into the loan appraisal process. This report presents all analyses in terms of both the TRC and Societal Cost Tests to meet the economic evaluation needs of MDB loan appraisal.

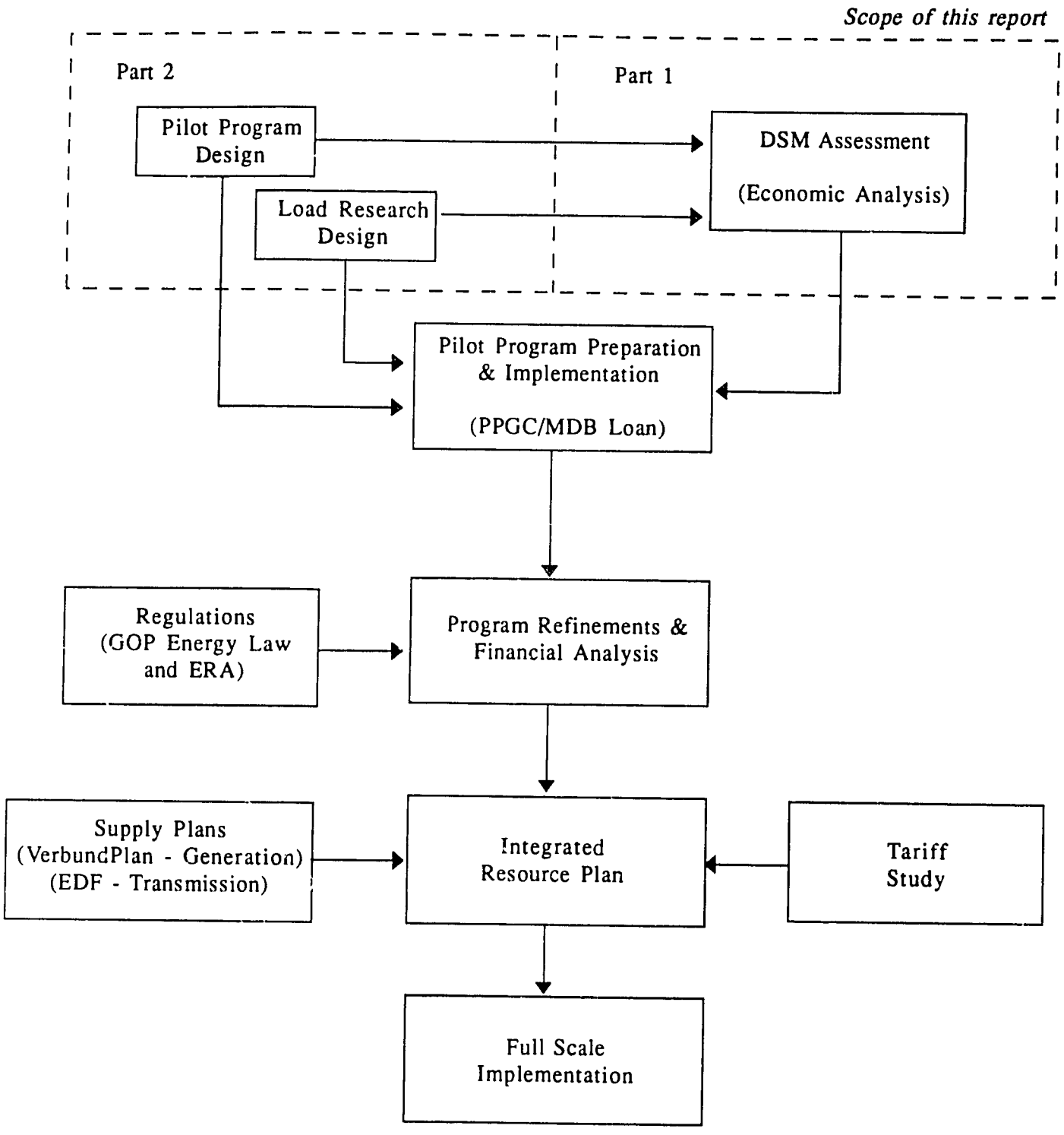
As noted in Section 1.1, the DSM assessment is just one element of a comprehensive power sector restructuring program. Exhibit 4 illustrates how this study fits into the broader restructuring effort. The results of this assessment and the load research and pilot project design activities aim to provide the basis for an MDB-financed DSM pilot effort. As energy regulations are formulated in Poland, further work will be necessary to conduct the financial analysis needed to refine the programs and ensure they are attractive to both utilities and consumers. This task need not wait until the pilot project has been implemented, but preliminary results from the pilot project could be taken into account as they become available. The final programs can then be introduced into the IRP analysis, which will also draw on the Supply Plan Study and the Tariff Study.

[5] For a further discussion of economic analysis including the distinction between market and shadow prices, see Squire and van der Tak, *Economic Analysis of Projects*, the World Bank/John Hopkins University Press, 1984.

Exhibit 3. Scope of the DSM Cost Tests

Tests	*Perspectives*	*Benefits*	*Costs*
(b) Ratepayer Impact Test	Non-Participants		- Rate Impacts of DSM
(a) Participant Test	Participants	+ Bill Savings	- Participant Net DSM Costs
(c) Utility Cost Test	Utility	+ Avoided Capital Costs + Avoided Operating Costs	- DSM Program Costs - Revenue Losses
(d) Total Resource Cost Test			
(e) Societal Cost Test	The Economy	+ Avoided Externality Costs	- Tax Benefits

Exhibit 4. The Role of the DSM Assessment



CHAPTER 2: ELECTRICITY USE IN POLAND

Demand-side resources are derived from changes in electricity consumption patterns. An assessment of DSM potential thus requires an understanding of how consumers use electricity. This chapter describes the principal electricity consumption patterns in Poland, which give rise to the technical opportunities for DSM, as well as consumer attitudes, which influence the extent to which these opportunities can be realized.

2.1 THE COMPOSITION OF ELECTRICITY DEMAND

A review of system load shapes can provide insight into customer behavior. System load data reflect aggregate consumer demand and can help determine load shape objectives for DSM programs.

Poland's average daily load shapes for each month are shown in Exhibit 5. These load shapes are based on 1991 hourly load data provided by PPGC. Annual average weekday and weekend load shapes are shown in Exhibit 6.

These exhibits reveal two dominant trends. The first is that system load increases as temperatures fall, i.e., during the winter. Although additional winter lighting requirements and summer vacation schedules contribute somewhat to relatively higher winter demand, the shift may be due primarily to heating requirements. However, electrical resistance space heating is relatively rare in Poland; an appliance survey of 107 households carried out by the Institute of Power Engineering indicated an electric heater saturation of only 12 percent. Instead, district heating is the predominant means of winter heating.[6] District heat pumping systems depend on thousands of motors which operate almost continuously during the heating season. For example, the Warsaw district heating company, SPEC, which produces about 3.4 percent of total thermal output in Poland, has several pump motors in the 800 kW to 1,500 kW range at a single CHP plant (Powisle). SPEC estimates that there are 50,000 pump motors in its system alone.

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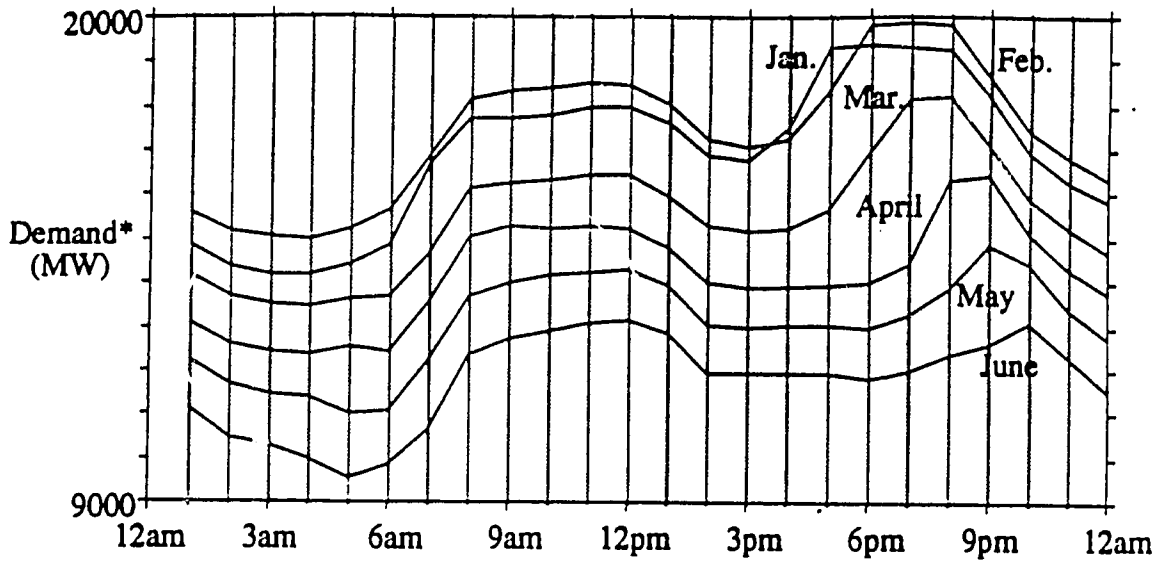
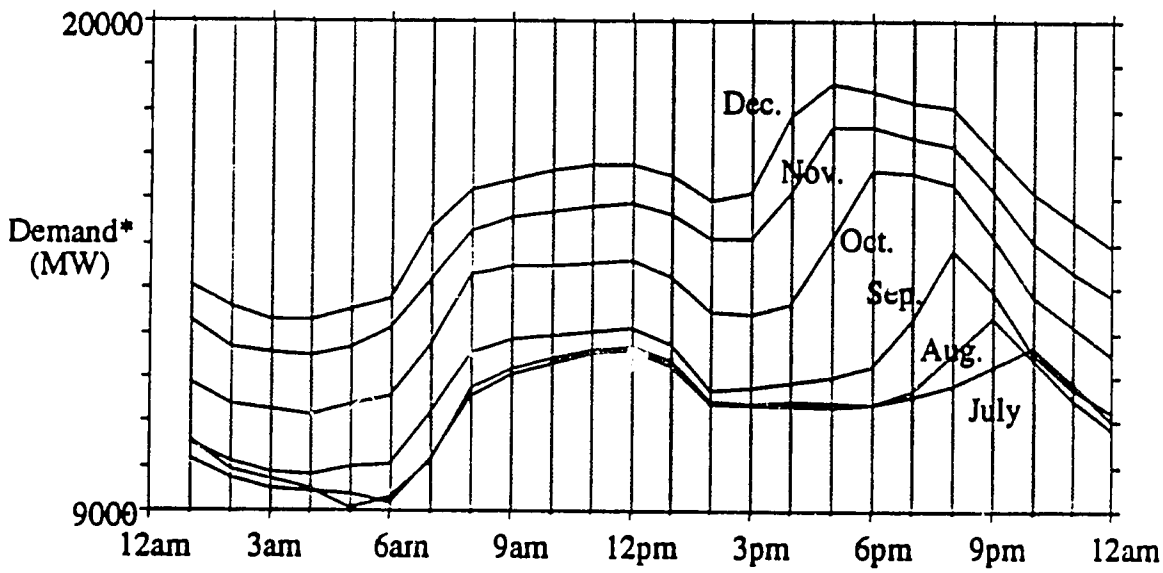
[6] Urban consumers, who are generally connected to district heating systems, account for most of Poland's residential electricity demand. In 1991, urban households represented nearly 79 percent of residential consumers and about 76 percent of annual residential sales. (Residential consumers are defined here as those within tariff classes G1, G2, and TP; they represent about 79 percent of all households. Farm consumers, which include farm households and correspond to tariff classes F1, F2, F11, and F21, represent about 21 percent of total households.) Urban consumers and sales likely account for even higher portions of the totals in the industrial and commercial sectors.

Exhibit 5
Average Daily Load Shape by Month, 1991



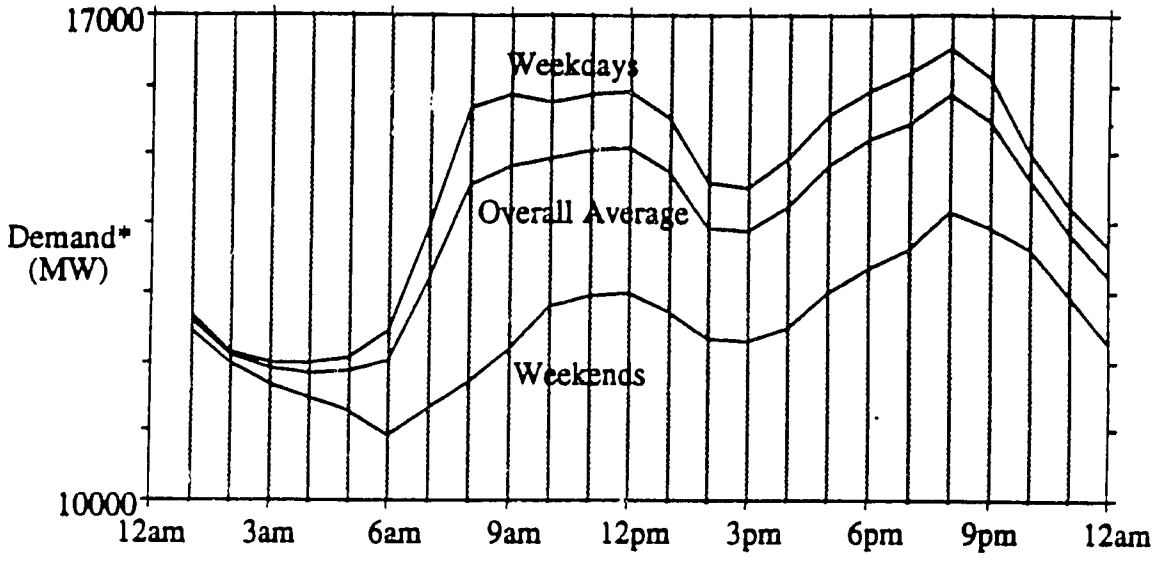
(a) January-June



(b) July-December

* Demand excludes pumped hydro load and autoproducer self-load.

Exhibit 6
Average Daily Load Shapes for Weekends and Weekdays, 1991



* Demand excludes pumped hydro load and auto-producer self-load.

The second observation is that the evening peak moves later into the evening and falls relative to the morning peak during the summer. This likely results from reduced lighting requirements during the summer.

As the Tariff Study points out, capacity is at a higher premium in the summer, even though the winter peak is greater. Despite lower peak demand, system reliability is lower in the summer because CHP plants are not available.

System load consists of several components. Exhibit 7 disaggregates total electricity sales by tariff class based on 1991 data. Tariff classes in Poland are defined in part by voltage level rather than consumer activity. Although some light industry is included in tariff class E, and some large commercial consumers are included in classes A and B, the clustering shown in Exhibit 7 is reasonably accurate. PPGC staff suggested that true industrial consumers account for 80 percent of class A and B sales. This is supported by a comparison between Exhibits 7 and 8.

Exhibit 7
Electricity Sales by Customer Class, 1991

Customer Class	Corresponding Tariff Classes	1991 Sales (GWh)	1991 Customers
Industrial	A2, A3, A11, A21, A31, B1, B2	51,052	44,859
Commercial	E1, E2, E11, E21	9,821	1,079,260
Agriculture (Farms only)	F1, F2, F11, F21	8,374	2,758,441
Residential	G1, G2, TP	20,829	10,322,305
Municipal Railways	A9 (TM)	670	224
National Railways	A9 (PKP)	4,245	537
Street Lighting	D	1,372	98,054
Total		96,384	14,303,680

2.2 THE INDUSTRIAL SECTOR

Exhibit 7 indicates that the industrial sector is Poland's dominant power consuming sector. Polish industry encompasses a wide range of activities. Exhibit 8 provides an overview of electricity use by large enterprises in the principal industrial subsectors.

In 1991, the fuels and energy subsector (principally coal mining) and metallurgy (principally steel mills) accounted for as much as half of industrial electricity consumption. However, subsectoral electricity consumption shares will change as Poland's economic transformation continues. Primary industries like coal mining and steel production are likely to decline as manufacturing and other downstream industries increase their shares. DSM measures that target these downstream industries are likely to offer higher persistence of savings since these consumers are more likely to still be operating a decade from now. Furthermore, these growth industries will probably make more capital investments over the coming years. These capital additions offer opportunities for DSM programs that encourage the installation of high-efficiency equipment.

Exhibit 8
The Composition of Industrial Electricity Demand

Industrial Subsector	Number of Enterprises*	Total 1991 Consumption (GWh)
Fuels & Energy**	113	9,230
Metallurgy	430	10,056
Manufacturing (Machinery)	1,073	5,735
Chemicals	337	6,369
Minerals	450	3,376
Wood & Paper	491	2,328
Textiles	705	1,548
Food	932	2,645
Other	244	319
Total	4,775	41,606

* The number of enterprises refers to those completing Central Statistical Office Questionnaires G-02 and G-03. These comprise only larger enterprises and represent a subset of all industrial consumers. In addition, the total number of consumers and total consumption presented in this table do not equal the totals for industrial consumers as they have been defined above because there are other high- and medium-voltage consumers in the "industrial" tariff classes which are not considered to be part of the industrial sector (e.g., large hotels). Nonetheless, the subsectors identified in this exhibit account for over 80 percent of total industrial sales.

** The fuels & energy subsector includes power generation. However, the number of enterprises and total consumption have been presented net of power stations (that is, they include only the coal and fuels industries).

A review of energy intensity values can also provide insight into industrial electricity consumption in Poland. Exhibit 9 compares energy intensities for selected industries in Poland, the United States, and Brazil. These results suggest that industrial electricity intensities are generally comparable in these countries.[7] However, this observation could be

[7] While electricity consumption per unit of physical output in Poland may be comparable to other countries, consumption per unit of GDP is much greater. This may be more a result of low GDP than high electricity consumption.

misleading since older technology in Poland produces inferior quality product and industry lacks pollution controls common in the West.

Exhibit 9
A Comparison of Industrial Electricity Intensities

	Electric Intensity, MWh/ton of Output		
Subsector	**Poland**	**United States**	**Brazil**
Non-Ferrous Metals	7.6	19.6 (aluminum only)	15.9
Iron and Steel	0.50	0.52	0.56
Paper and Pulp	0.89	1.26	0.87
Textiles	9.8	4.7	3.1
Cement	0.13	0.13	0.11

Sources: Poland - Central Statistics Office, *Fuel and Energy Statistics, 1990-91*.
United States - Electric Power Research Institute, *U.S. Manufacturing Sector Overview*, Research Project 2893-11, 1993.
Brazil - H. Geller, *Efficient Electricity Use: A Development Strategy for Brazil*, ACEEE, 1991.

Principal Industrial End-Uses

Motors, processes (e.g., electrolysis or heating), and lighting account for virtually all industrial load in Poland. Whereas primary industries may be more process intensive, Poland's growth industries are likely to be more motor intensive. End-use shares for Polish industry have not been determined; the load research program outlined in Part 2 of this report will help determine these shares. In the meantime, this analysis assumes that 70 percent of electricity consumption by Polish industry is for motors, 20 percent is process related, and 10 percent is for lighting. This breakdown is consistent with experience elsewhere.[8]

[8] Motors account for 78 percent of electricity consumption in the United States (Nadel et al., *Energy Efficient Motor Systems*, ACEEE, 1992), 49 percent in Brazil, which has large process loads for non-ferrous

As part of this project, the Institute of Power Engineering in Katowice carried out a statistical analysis of metered loads to derive customer class load curves. Average daily normalized load shapes were derived for the winter (October through March) and summer (April through September) seasons. The Polish Foundation for Energy Efficiency simultaneously gathered information on the stock and use of end-use equipment. The population characteristics of industrial end-use equipment are presented in Exhibit 10 based on their findings.

Compared to the United States, the motor size distribution in Poland is skewed towards larger motors. This is in part due to oversizing, but also reflects the higher degree of industrial centralization in Poland, as well as end-uses such as district heat pumping, which call for larger motors. Most lighting consists of fluorescent lamps, but there is also significant utilization of incandescent bulbs and mercury vapor lamps; the "other" lighting category represents high-pressure sodium lamps and other lighting installations which would not be good candidates for efficiency improvements because of either cost or technical applicability of alternatives. Process loads have not been disaggregated because there are insufficient data to prepare an inventory of even the major process loads in Poland, which are highly industry specific.

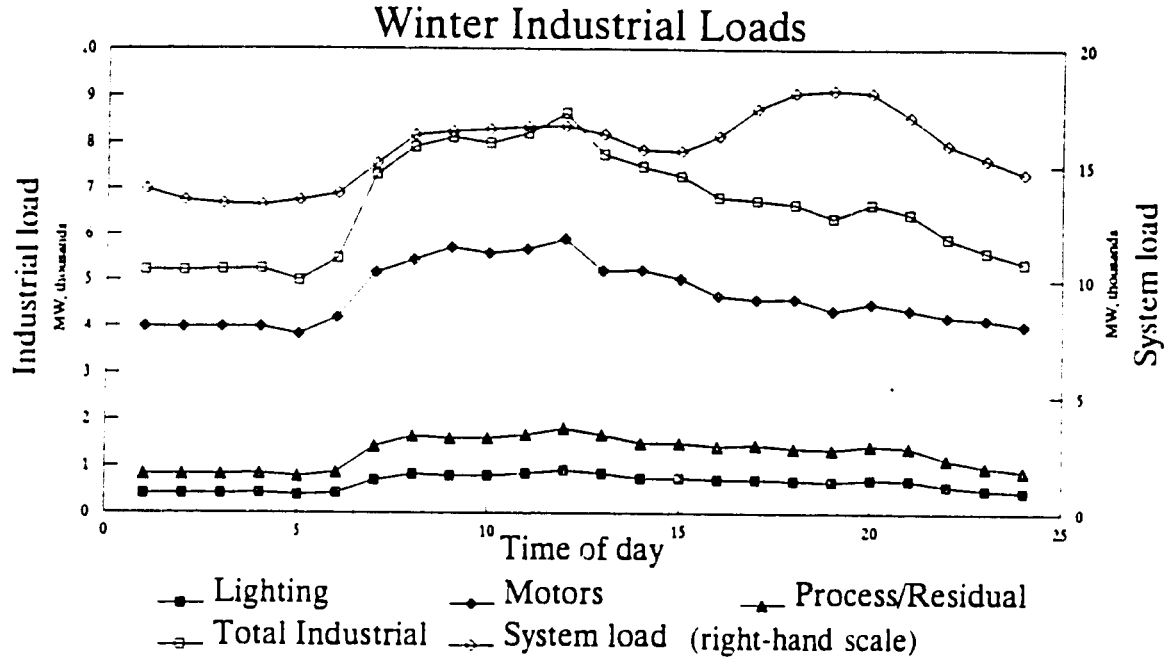
Industrial end-use load shapes for Poland were derived by combining the customer class load curves with the inventory of end-use equipment and end-use allocation of total annual industrial consumption. It was assumed that the minimum difference between summer and winter load curves (i.e., the difference at 3 a.m.) was attributable solely to motor loads associated with heating system operation. Since heat system operation varies relatively little on a diurnal basis, it was further assumed that the quantity of additional motor load remained constant throughout the day. One-third of the remaining difference during other hours of the day was allocated as additional lighting load, and two-thirds as additional process loads. Customer class and end-use load shapes are shown in Exhibit 11, along with the system load curve. This exhibit suggests that although industrial loads represent the largest single share of electric energy consumption, they account for a proportionally smaller share of peak system demand.

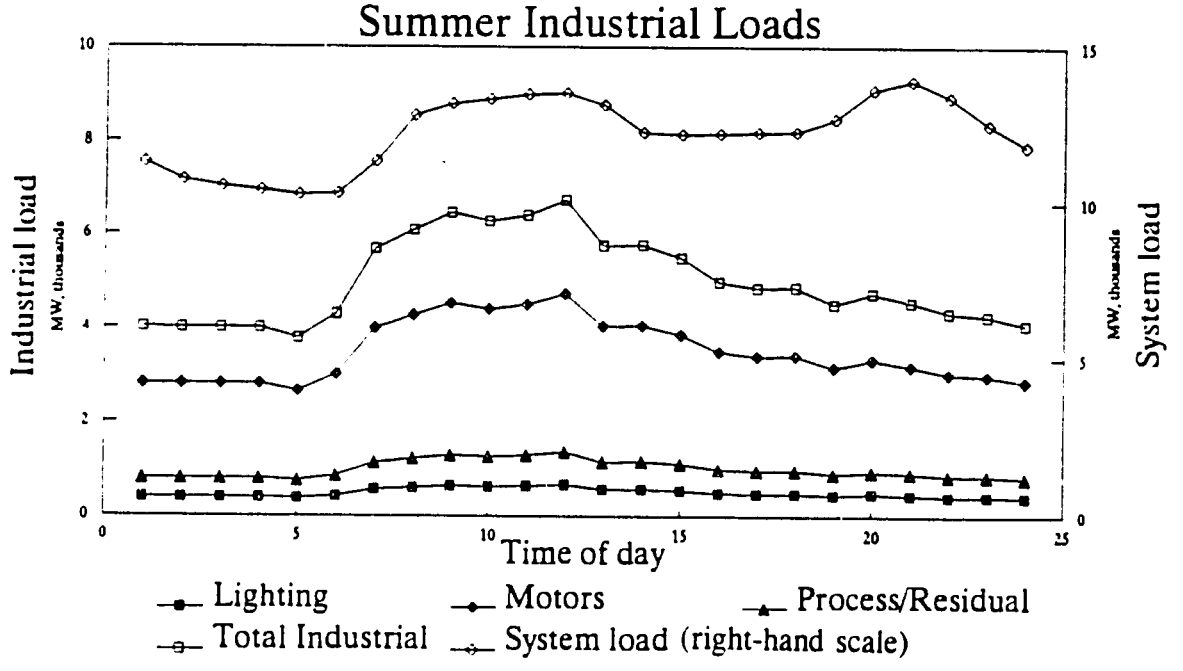
metal production (Geller, op. cit, p. 24), and 74 percent in India (Nadel et al., *Opportunities for Improving End-Use Electricity Efficiency in India, USAID* 1991).

Exhibit 10
Industrial End-Use Equipment in Poland

End-Use	Avg. kW per Installation	Annual Hours of Operation	Number of Installations	Total Annual Consumption (GWh)
Motors				
Small Motors	3.5			
- high use		5,840	160,000	3,270
- low use		1,800	800,000	5,040
Medium Motors	17.5			
- high use		5,840	50,000	5,110
- low use		1,800	225,000	7,087
Large Motors	120			
- high use		5,840	5,000	3,504
- low use		2,400	20,000	5,760
Very Large Motors	1,200			
- high use		5,840	400	2,803
- low use		3,300	800	3,168
Subtotal	-	-	1,261,200	35,742
Lighting				
Fluorescent (2 lamp fixtures)				
- high use	0.095	5,840	5,000,000	2,774
- low use	0.036	1,800	10,000,000	648
Mercury Vapor	0.210	3,650	700,000	537
Incandescent	0.300	3,650	500,000	548
Other	-	-	-	598
Subtotal	-	-	-	5,105
Process	-	-	-	10,210
Total Industrial	-	-	-	51,057

Exhibit 11
Industrial End-Use Load Shapes, Winter and Summer





Industrial Customer Attitudes and Constraints

Focus groups were conducted with industrial consumers as part of the pilot program design described in Part 2 of this report In addition, the Tariff Study reviewed the impact of tariff increases on industrial consumers. These two activities reveal some general characteristics of industrial consumers that are relevant to this assessment of DSM potential:

- Many industries, particularly heavy industry, are still state-owned and are likely to remain so at least in the near term. While a sweeping privatization law was passed in April 1993 and the government has made privatization a key part of the economic restructuring program, it is not clear when (or in what form) privatization will occur. As of late 1992, private industry accounted for only 24 percent of industrial output. The large, state-owned industrial enterprises face few incentives that would be necessary to encourage their participation in DSM programs.

- The Tariff Study reports that although some industries such as aluminum production are exceptions, electricity typically accounts for between 1 and 5 percent of total production costs, and averages around 3.4 percent. Under the current circumstances in which many industries are struggling just to survive, reducing electricity costs is a secondary concern. In addition to a lack of incentives to improve efficiency, many firms cannot devote the time or effort needed to address this relatively small part of their expenses, even if incentives are in place.

- There is little tradition of energy saving in Polish industries. Under the previous economic system, incentives were provided primarily for the maximization of output rather than the minimization of costs. Industrial representatives identified financial incentives, both for individual employees and at the plant level, as the most effective way to promote energy efficiency.

- Industrial representatives repeatedly noted that the greatest energy savings potential lies in automated monitoring and control of industrial operations. This is reflected in the results of the screening analysis presented in Chapter 3.

- There are substantial differences of opinion between large and small enterprises regarding interaction with the utility. Large, usually state-owned, industries seem to be suspicious of utilities. They often feel that utilities have little to offer in terms of assistance regarding energy efficiency. Small industries, on the other hand, appear more willing to work with utilities on reducing energy consumption. They are more likely to view utilities as service providers than as commodity producers. While large

companies were much more rigid in their investment criteria for DSM measures (e.g., investments had to have a certain payback time), small companies indicated a willingness to consider any measure that could improve their market position.

- Although large and small companies differed over the role of the utility, they both felt that if the utility were to promote DSM, it should encompass both technical and financial assistance.

Although industry may offer the greatest economic DSM potential, it may be more difficult to achieve this potential than in either the commercial or residential sectors.

2.3 THE COMMERCIAL SECTOR

As shown in Exhibit 7, the commercial sector accounts for over ten percent of total electrical consumption in Poland. This program is much smaller than in the United States and it comprises different end-uses.

Principal Commercial End-Uses

In warm climates, heating, ventilating, and air conditioning (HVAC) is a major component of commercial electric load. In the United States, HVAC represents about 41 percent of total commercial consumption.[9] In Poland, air conditioning is generally not required, heating is provided through district networks, and ventilation has limited use; commercial HVAC is therefore relatively insignificant.

Exhibit 12 compares lighting levels in the United States and Poland. Although lighting levels are far lower in Poland than in the United States, non-lighting commercial loads are also much smaller, so that the lighting share remains comparable when expressed in percentage terms. The lower levels of illumination found in Poland will influence the DSM measures available in Poland. This is discussed further in Chapter 3.

[9] Electric Power Research Institute, *Efficient Electricity Use: Estimates of Maximum Energy Savings*, Report CU-6746, 1990.

Exhibit 12
Comparison of Polish and U.S. Illumination Levels
(values expressed in lux)

Building Type	Poland	United States
Schools	240 - 400	325 - 1,600
Shops	80 (interiors) 600 (displays)	215 - 540 (interiors) 1,100 - 2,200 (displays)
Factories	80 - 400	540 - 10,000 540 for ordinary tasks
Offices	240	325 - 1,100
Hotels	80 (lobby) 160 - 240 (rooms)	110 - 540 (rooms and lobbies)
Restaurants (dining areas)	160	215 - 540
Hospitals	160	110 - 540
Libraries	240	325 - 1,100

Sources: Poland - Survey of architects conducted by FEWE; values reflect actual practice.
United States - Illuminating Engineering Society of North America, *IES Lighting Handbook, 1981*; minimum design values are given, which are generally followed in practice.

This discussion focuses solely on lighting because the diversity of and lack of information on the remaining non-lighting commercial loads make it difficult to characterize these loads. Furthermore, because the non-lighting commercial load is so diverse, it is unlikely that any of these measures taken alone will yield significant impacts on a national level. Exhibit 13 presents a commercial sector end-use inventory, focused on lighting, based on the work carried out by FEWE.

It is assumed that lighting load varies with total commercial load. Exhibit 14 shows the commercial lighting load shapes for winter and summer based on the data collected by the Institute of Power Engineering and the assumption that lighting accounts for 60 percent of load.

Exhibit 13
Commercial Sector End-Uses in Poland

End-Use	Avg. kW per Installation	Annual Hours of Operation	Number of Installations	Total Annual Consumption (GWh)
Fluorescent Lighting				
- high use	0.095	3,500	5,000,000	1,663
- low use	0.036	1,800	12,000,000	778
Incandescent Lighting				
- high use	0.060	3,500	6,000,000	1,260
- low use	0.075	1,800	12,000,000	1,620
Other Lighting*	-	-	-	540
Lighting Subtotal	-	-	-	5,861
Non-Lighting	-	-	-	3,960
Commercial Sector Total	-	-	-	9,821

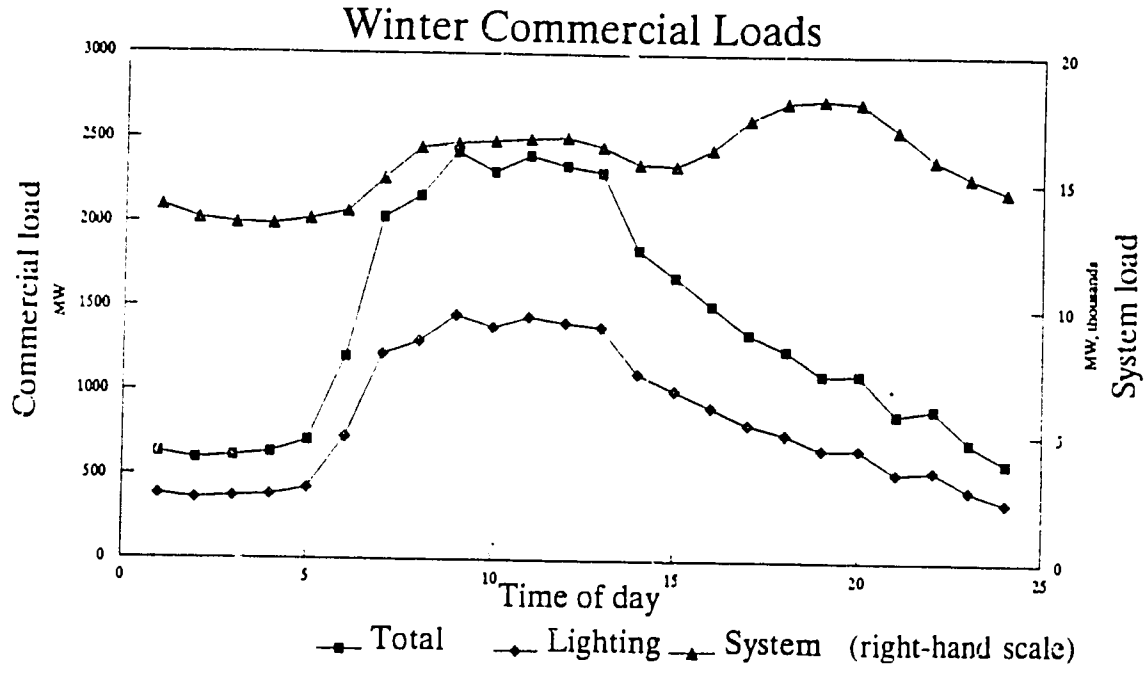
* "Other Lighting" includes neon, halogen, high pressure sodium, and other specialty lighting.

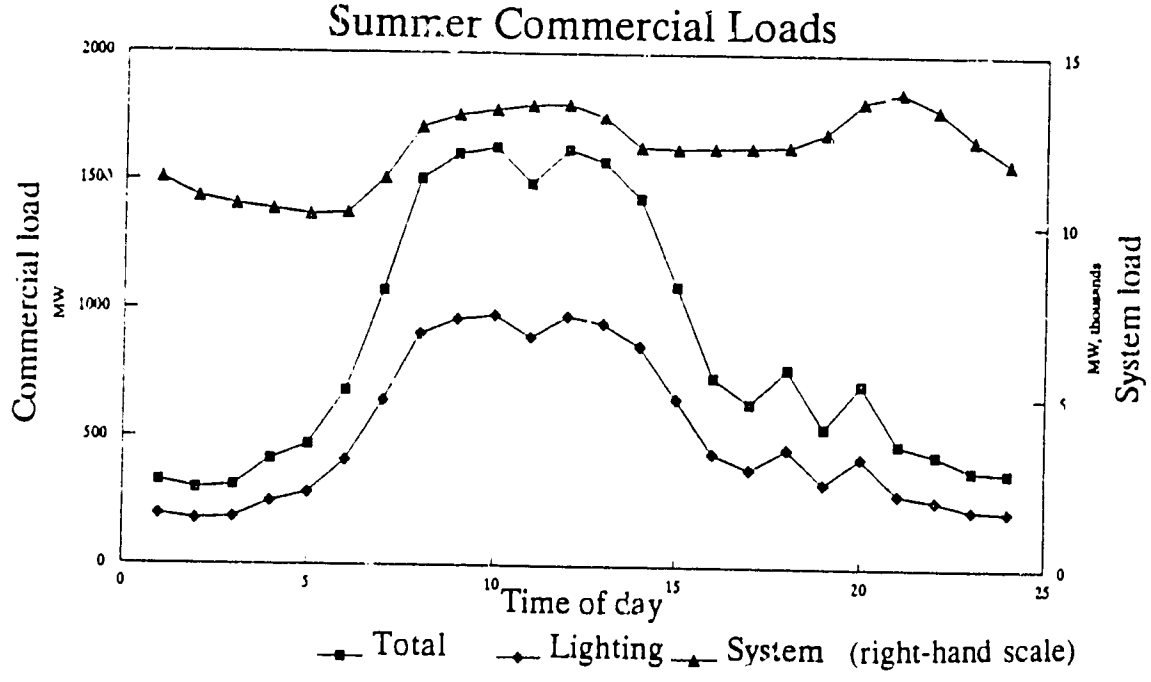
Commercial Customer Attitudes and Constraints

Like the industrial sector, the commercial sector in Poland is a heterogeneous group; unlike the industrial sector, it has a large number of small enterprises. The commercial class comprises a wide range of consumers, including shops, offices, schools, and hospitals. The focus groups revealed two principal categories among these consumers: non-profit enterprises, such as schools, hospitals, and municipal offices; and for-profit enterprises such as retail shops and company offices.

Non-profit enterprises depend upon public budgets for investment and operation. Because of the pressures on the public budgets at the current time, these enterprises rarely receive the resources they request. They are keen to cut costs, of which energy may be a significant share; one hospital indicated that energy costs accounted for 30 percent of all its expenses. For-profit enterprises, on the other hand, have greater control over their own budgets. Insofar as they can pass costs on to the consumer, they actually feel less incentive to cut electricity expenditures.

Exhibit 14
Commercial End-Use Load Shapes, Winter and Summer





Both non-profit and for-profit focus group participants identified lighting as their primary electric end-use, and energy-efficient lighting as the largest and most easily implemented DSM opportunity. They also have relatively favorable attitudes towards the utility, and appear willing to cooperate with the utility. Among both groups, prices are the primary criterion for equipment selection; financial assistance (either as payments for savings or rebates for purchases) from the utility would be the most effective way of encouraging participation in DSM programs. Although the technical savings potential is far less in the commercial sector than the industrial sector, the willingness of commercial enterprises to work with utilities on DSM implementation makes the commercial sector a fertile DSM market segment.

2.4 THE RESIDENTIAL SECTOR

The residential sector is the second-largest electricity consuming sector in Poland after the industrial sector. The bulk of residential load is lighting, which is highly coincident with system peak demands. In addition to the importance of the residential sector from the standpoint of technical potential, equity considerations dictate that residential consumers have opportunities to participate in DSM programs, which can reduce their electric bills. As in other sectors, this will require an understanding of residential demand patterns as well as customer attitudes.

Although farm households are allocated to the agricultural tariff class, this analysis includes them as part of the residential sector. In 1991, there were 10,322,305 consumers in the residential tariff classes, and 2,758,441 in the agricultural tariff classes. Combining these two, and assuming an average annual residential consumption of 2,016 kWh/yr (derived from the residential tariff class statistics), total residential consumption is estimated to be 26,731 GWh/yr, or 27.4 percent of 1991 total domestic sales.[10]

[10] This may somewhat understate residential consumption, since rural consumers in the residential tariff classes consume 2,174 kWh/yr compared to 1,923 kWh/yr among urban consumers (source: *Statystyka Electroenergetyki Polskiej*, 1991, Ministry of Industry Energy Information Center). Instead of assuming that farm households consume at the rural residential rate, we assume that they consume at the average rate of all households in the residential tariff class.

Principal Residential End-Uses

Incandescent lighting is the largest single residential end-use, accounting for 55 percent of total residential demand; appliances account for the remaining demand. Exhibit 15 lists the principal end-uses within the residential sector. Appliance saturation is not as great as in western Europe or the United States. These levels of saturation will accommodate considerable growth in residential electricity demand as household incomes rise and the acquisition of appliances accelerates.

Exhibit 16 shows the daily residential load curves by season. Residential load peaks at the time of system peak. This coincidence, as well as seasonal changes in overall residential loads, is driven by lighting. The residential peak exceeds the industrial peak. However, because only a fraction of the large stock of residential lighting is on at the system peak time, individual customer coincidence factors are lower in the residential sector than in the industrial sector.

Residential Customer Attitudes and Constraints

Household response to DSM programs will depend in part on the value of participation in terms of bill reductions. According to the tariff study, households currently spend about 2 percent of their income on electricity. This is consistent with household electricity expenditures in a wide range of countries; in the United States, for example, electricity represents about 2.2 percent of total personal consumption expenditures. Therefore, on the basis of electricity expenditure shares alone, residential DSM program response should be no better or worse than in other countries.

Residential consumers in Poland may nonetheless become easily disenchanted with DSM programs as a result of the electricity billing system. Most residential meters are located inside the customer premises. Recognizing that utility staff can obtain only infrequent access to meters,[11] all residential consumers receive a payment book at the beginning of the year with payments to be sent in bi-monthly. These payments are estimated on the basis of prevailing rates and the previous year's consumption. At the end of the year, the actual annual bill is reconciled with the payments made from the payment book, taking into account changes in tariffs as well as consumption. Because of regular and substantial tariff increases, most customers must pay a large amount at the end of the year to reconcile the account.

[11] It is not uncommon for meters to be unread for as long as two years.

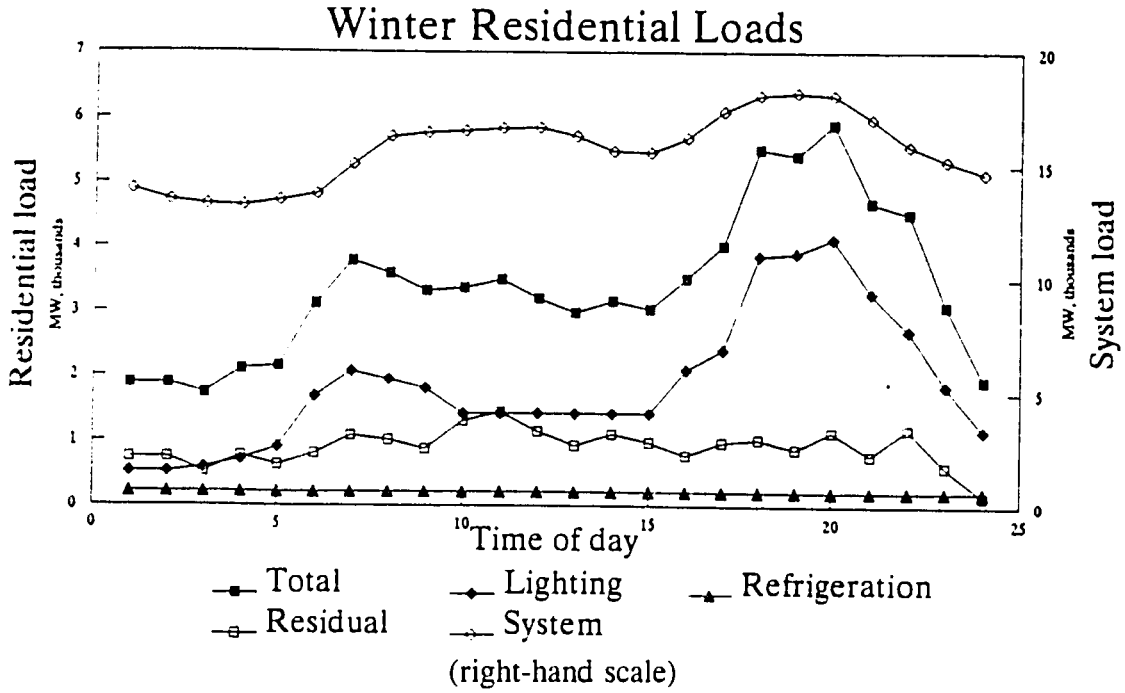
Exhibit 15
Residential End-Use Equipment in Poland

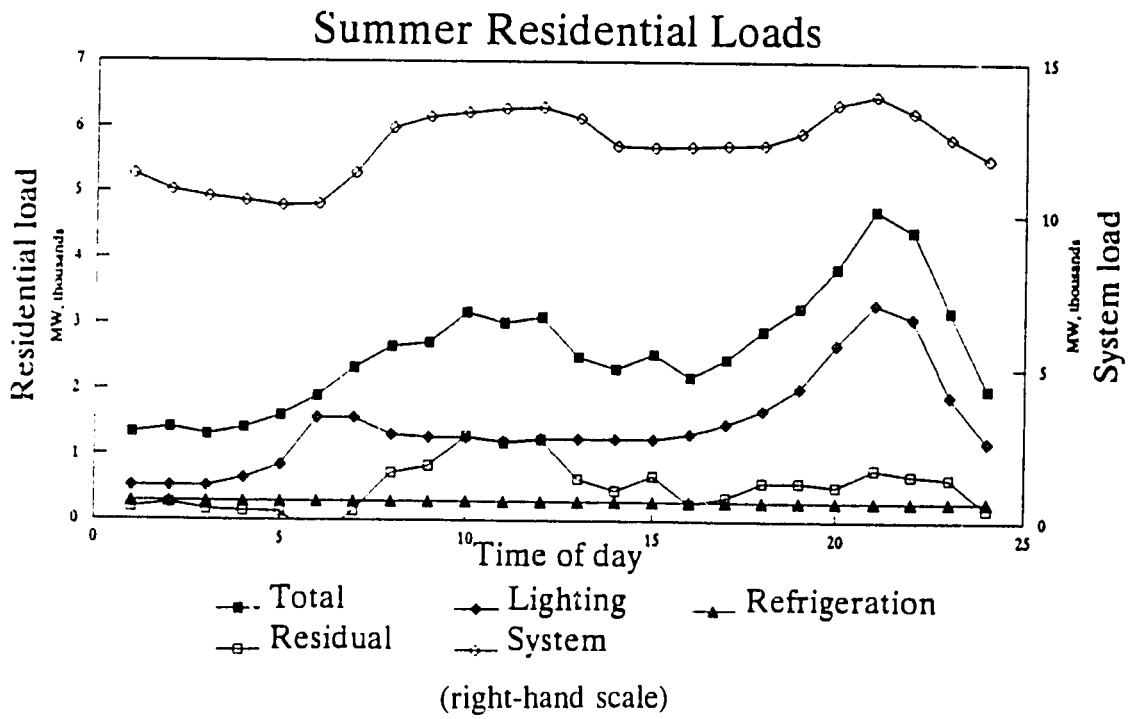
End-Use	Avg. kW per Installation	Annual Hours of Operation	Number of Installations	Total Annual Consumption (GWh)
Lighting				
Incandescent				
- low use	0.075	900	160,000,000	10,800
- high use	0.050	3,000	25,000,000	3,750
of which high wattage	0.075	3,000	6,000,000	1,350
Subtotal	-	-	-	14,550
Refrigerators				
Large (> 170 lt)	0.300	-	8,340,400	3,945
Small (< 170 lt)	0.220	-	3,574,000	1,467
Subtotal	-	-	-	5,412
Storage Water Heaters				
Large (100 - 160 lt)	-	-	600,000	600
Small (10 - 50 lt)	-	-	1,400,000	560
Subtotal	-	-	-	1,160
Other Appliances				
Televisions				
- black & white	0.200	-	7,560,100	-
- color	0.150	-	7,721,500	-
Freezers	-	-	2,868,000	-
Washing machines				
- drum type	-	-	8,593,000	-
- automatic	-	-	5,824,000	-
Subtotal (includes all other end-uses not listed)	-	-	-	5,609
Total	-	-	-	26,731

Source: FEWE

98

Exhibit 16
Residential End-Use Load Shapes, Winter and Summer





Even in cases in which electricity consumption has declined, the year-end settlement could give the impression that program participation does not pay. The residential focus groups confirmed this assertion.

The focus groups revealed that households have little information on higher efficiency end-use alternatives, except that they know they are more expensive on a first-cost basis. In particular, they are largely unaware of the benefits of these measures. Furthermore, customers do not know how much they are consuming from month to month. Consumers have no information to help them optimize their electricity consumption usage. Clearly, residential DSM programs in Poland must be packaged with measures which provide consumers with better information about their electricity use and options, and which make the benefits of program participation readily apparent.

As in the industrial sector, households need both technical and financial assistance in order to adopt DSM measures. Households that participated in the focus groups indicated that although they would be willing to work with the utilities to gain this assistance, they are wary because they feel utilities previously have not shown they recognize the consumers' interests. As in other sectors, DSM program success will require not only technical capability and financial support of the utility, but also the ability of the utility to overcome customer perceptions of its past performance and to demonstrate that it is a service provider and not a commodity producer.

CHAPTER 3: IDENTIFYING DEMAND-SIDE RESOURCES

Just as utility system needs dictate the selection of supply-side technologies, demand-side resources can only be defined in terms of system requirements. This chapter describes those system requirements in terms of load shape objectives, and identifies potential technical measures to meet those objectives. These measures are screened for economic viability by comparing the cost of saved energy for each measure with the long-run avoided generation cost. Measures that pass this screening form the basis for programs described and assessed with DSManager in Chapter 4.

3.1 LOAD SHAPE OBJECTIVES

Exhibit 2 provided a taxonomy of load shape objectives that can be met by DSM. Some of the salient points regarding the Polish power system that help determine the appropriate objectives are summarized below:

- New generation capacity additions are expected in Poland as early as 1996, despite a decline in electricity sales over the past few years. Extensive plant rehabilitation is also expected over the 1993-2000 time period. Peak clipping, load shifting, and flexible load shapes can obviate or defer capacity additions and rehabilitation needs.

- Approximately 99.5 percent of Poland's electricity is produced from coal- or lignite-fired plants. Although the employment impacts of reduced coal and lignite consumption should be taken into account, the use of these fuels has considerable environmental costs. Electricity conservation would help reduce these costs (and may offer net employment growth as well if carried out through a properly designed DSM program).

- New transmission and distribution capacity additions are planned for the next several years. Approximately one-half of the cost of a system peak coincident kilowatt of demand at the low-voltage level is attributable to transmission and distribution capacity. Conservation and peak clipping would help reduce or defer transmission and distribution additions.

- Load factor for the Polish grid is currently around 65 percent. This is an above-average load factor, which suggests that prospects for increasing the load factor are

limited at best. The benefits of higher capacity utilization would not likely outweigh the economic costs of valley filling.

Although the IRP analysis will ultimately judge the value of particular demand-side resources, the above points suggest that the DSM measures most appropriate for Poland are those which reduce peak demands and save energy.

3.2 POTENTIAL DSM MEASURES

Measures to improve electric end-use efficiency and better manage peak load will vary with the sector and end-use. The search for appropriate measures will focus on the sectors and end-uses discussed in Chapter 2:

- *Residential:* lighting, refrigeration, and water heating. These end-uses account for approximately 79 percent of residential consumption, or about 22 percent of total consumption.

- *Commercial:* lighting. This end-use accounts for 60 percent of commercial consumption, or 6 percent of total consumption.

- *Industrial:* lighting and motors, although some measures will address overall industrial use. Lighting and motors alone account for about 80 percent of industrial demand, or 42 percent of total consumption.

- *Street lighting:* this end-use accounts for about 1 percent of consumption.

Thus, this assessment considers measures that target end-uses accounting for about 70 percent of total domestic consumption. No measures are discussed regarding industrial process loads (11 percent of total domestic consumption) and very large motors (6 percent), commercial non-lighting loads (4 percent) and specialty lighting loads (1 percent), municipal and national electric railways (5 percent), agricultural machinery (3 percent), or remaining residential loads (6 percent). These omitted end-uses either offer limited technical opportunities for DSM, or are very heterogeneous and hence beyond the scope of the basic data acquisition activities undertaken to support this assessment. To the extent these sectors and end-uses are not included in the analysis, this assessment understates total DSM potential in Poland.

GV

On the other hand, the assessment does consider a broad cross section of sectors and end-uses that represent the bulk of electricity consumption in the country. Since these end-uses are relatively homogeneous compared to those that have been omitted, measures can be replicated and disseminated far more easily. These measures likely represent a larger portion of total achievable DSM potential than their corresponding share of total consumption suggests. These measures therefore represent the majority of cost-effective, achievable DSM potential in Poland.

The following sections describe potential DSM measures for each sector and end-use which, if shown to be economically justified, could form the basis for a DSM program. Two factors affect economic attractiveness:

- ***Retrofit vs. replacement.*** One factor is whether the technical intervention, such as the installation of a higher-efficiency end-use device, is made when the existing conventional equipment is due to be replaced. If so, it is termed a "replacement." If not (i.e., if the technical intervention is made regardless of the condition or remaining life of the existing equipment), it is referred to as a "retrofit." One economic benefit of a replacement that does not accrue to a retrofit is the savings that result from not having to purchase a new piece of standard equipment to replace the end-use device, since it is already being replaced with the improved equipment.

- ***Annual hours of use.*** Another important factor is the amount of time that the end-use is in operation (the duty cycle). Most measures are designed to improve the efficiency of the end-use and thereby reduce system load. The more hours per year that an end-use operates, the greater the energy savings from a measure that improves efficiency, and the greater the economic benefits.

These factors are used to disaggregate the measures associated with each end-use into classes of varying economic attractiveness. This disaggregation provides a more accurate estimate of the total economic potential for DSM in Poland, as well as a more effective screen for determining which measures are good candidates for further program design and assessment.

Exhibit 17 lists the conventional end-uses and potential DSM measures considered for Poland along with their economic and technical characteristics. These characteristics are based on a variety of sources from both Poland and the United States, which are documented at the end of Exhibit 17. Only measures that provide the same quality of service as the standard equipment are considered. Costs are reported in economic terms (i.e., in border price equivalents), not in financial terms.

Exhibit 17: Technical and Economic Characteristics of Conventional End-Uses and Potential DSM Measures in Poland

No	Measure	Number of eligible installations	Annual hours of operation	Annual consumption of measure, kWh/yr	Annual consump. of standard equipment, kWh/y	Cost of standard equipment, $	Labor hrs for standard equipment	Cost of measure, $	Labor hrs for measure	Life of standard equipment, hours or years	Life of measure, hours or years	Power consumption of standard equipment, kW	Power consumption of measure, kW	Coincidence factor (a)
	RESIDENTIAL (22% of sales)													
1	Replace small refrigerators (approx. 150 l) upon retirement with 1990 US average	3,574,000 (FEWE)		255 (OTA)	411 (FEWE)	119 (FEWE)	0.00	142 (LBL 1)	0.00	20 (FEWE)	20	0.220 (FEWE)	0.152 (b)	0.19
2	Replace small refrigerators (approx. 150 l) upon retirement with 1993 US standard	3,574,000 (FEWE)		198 (OTA)	411 (FEWE)	119 (FEWE)	0.00	168 (LBL 1)	0.00	20 (FEWE)	20	0.220 (FEWE)	0.167 (b)	0.19
3	Replace large refrigerators (approx. 250 l) upon retirement with 1990 US average	8,340,368 (FEWE)		294 (OTA)	473 (FEWE)	139 (FEWE)	0.00	167 (LBL 1)	0.00	20 (FEWE)	20	0.300 (FEWE)	0.207 (b)	0.19
4	Replace large refrigerators (approx. 230 l) upon retirement with 1993 US standard	8,340,368 (FEWE)		228 (OTA)	473 (FEWE)	139 (FEWE)	0.00	195 (LBL 1)	0.00	20 (FEWE)	20	0.300 (FEWE)	0.228 (b)	0.19
5	Wrap water heaters	2,000,000 (FEWE)		522 (EPS)	580 (FEWE)	0	0.00	7 (HD)	0.50	0	8 (FEWE)			0.07
6	Replace low-use incandescent lamps with CFLs upon retirement	160,000,000 (FEWE)	900 (FEWE)	20 (EPS)	66 (FEWE)	0.44 (FEWE)	0.10	15 (FEWE)	0.10	1,000 (FEWE)	10,000 (EPS,RG)	0.075 (FEWE)	0.022 (EPS)	0.27
7	Replace hi-use incandescent lamps with CFLs upon retirement	25,000,000 (FEWE)	3,000 (FEWE)	36 (EPS)	150 (FEWE)	0.37 (FEWE)	0.10	15 (FEWE)	0.10	1,000 (FEWE)	10,000 (EPS,RG)	0.050 (FEWE)	0.012 (EPS)	0.27
8	Retrofit low-use incandescent lamps with CFLs	160,000,000 (FEWE)	900 (FEWE)	20 (EPS)	66 (FEWE)	0.44 (FEWE)	0.10	15 (FEWE)	0.10	1,000 (FEWE)	10,000 (EPS,RG)	0.075 (FEWE)	0.022 (EPS)	0.27
9	Retrofit hi-use incandescent lamps with CFLs	25,000,000 (FEWE)	3,000 (FEWE)	36 (EPS)	150 (FEWE)	0.37 (FEWE)	0.10	15 (FEWE)	0.10	1,000 (FEWE)	10,000 (EPS,RG)	0.050 (FEWE)	0.012 (EPS)	0.27
10	Replace hi-use, hi-wattage incandescent lamps with CFLs	6,000,000 (c)	3,000 (FEWE)	66 (EPS)	225 (FEWE)	0.44 (FEWE)	0.10	15 (FEWE)	0.10	1,000 (FEWE)	10,000 (EPS,RG)	0.075 (FEWE)	0.022 (EPS)	0.27
	COMMERCIAL (10% of sales)													
11	Replace low-use fluorescent ballasts with efficient core-coil ballasts upon retirement	12,000,000 (FEWE)	1,800 (FEWE)	59 (LBL 2)	64 (calc.)	18 (FEWE)	0.30	23 (LBL 2)	0.30	40,000	45,000 (LBL 2)	0.036 (d)	0.033 (LBL 2)	0.19
12	Replace hi-use fluorescent ballasts with efficient core-coil ballasts upon retirement	5,000,000 (FEWE)	3,500 (FEWE)	308 (LBL 2)	333 (calc.)	26 (FEWE)	0.30	31 (LBL 2)	0.30	40,000	45,000 (LBL 2)	0.095 (LBL 2)	0.087 (LBL 2)	0.19
13	Replace low-use fluorescent lamps & ballasts with T-8 lamps and solid state ballast	12,000,000 (FEWE)	1,800 (FEWE)	44 (LBL 2)	64 (calc.)	18 (FEWE)	0.30	54 (EPS)	0.30	40,000 (LBL 2)	70,000 (LBL 2)	0.036 (d)	0.024 (LBL 2)	0.19
14	Replace hi-use fluorescent lamps & ballasts with T-8 lamps and solid state ballast	5,000,000 (FEWE)	3,500 (FEWE)	228 (LBL 2)	333 (calc.)	26 (FEWE)	0.30	62 (EPS)	0.30	40,000 (LBL 2)	70,000 (LBL 2)	0.095 (LBL 2)	0.066 (LBL 2)	0.19
15	Retrofit low-use fluorescent ballasts with efficient core-coil ballasts	12,000,000 (FEWE)	1,800 (FEWE)	59 (LBL 2)	64 (calc.)	18 (FEWE)	0.30	23 (LBL)	0.30	40,000 (LBL 2)	45,000 (LBL 2)	0.036 (d)	0.033 (LBL 2)	0.19
16	Retrofit hi-use fluorescent ballasts with efficient core-coil ballasts	5,000,000 (FEWE)	3,500 (FEWE)	308 (LBL 2)	333 (calc.)	26 (FEWE)	0.30	31 (LBL)	0.30	40,000 (LBL 2)	45,000 (LBL 2)	0.095 (LBL 2)	0.087 (LBL 2)	0.19
17	Retrofit low-use fluorescent lamps & ballasts with T-8 lamps and solid state ballast	12,000,000 (FEWE)	1,800 (FEWE)	44 (LBL 2)	64 (calc.)	18 (FEWE)	0.30	54 (EPS)	0.30	40,000 (LBL 2)	70,000 (LBL 2)	0.036 (d)	0.024 (LBL 2)	0.19
18	Retrofit hi-use fluorescent lamps & ballasts with T-8 lamps and solid state ballast	5,000,000 (FEWE)	3,500 (FEWE)	228 (LBL 2)	333 (calc.)	26 (FEWE)	0.30	62 (EPS)	0.30	40,000 (LBL 2)	70,000 (LBL 2)	0.095 (LBL 2)	0.066 (LBL 2)	0.19
19	Replace low-use incandescent lamps with CFLs upon retirement	12,000,000 (FEWE)	1,800 (FEWE)	49 (calc.)	135 (calc.)	0.44 (FEWE)	0.10	15 (FEWE)	0.10	1,000 (FEWE)	10,000 (EPS,RG)	0.075 (FEWE)	0.027 (EPS,RG)	0.19

Exhibit 17: Technical and Economic Characteristics of Conventional End-Uses and Potential DSM Measures in Poland (cont'd.)

No	Measure	Number of eligible installations	Annual hours of operation	Annual consumption of measure, kWh/yr	Annual consumption of standard equipment, kWh/y	Cost of standard equipment, $	Labor hrs for standard equipment	Cost of measure, $	Labor hrs for measure	Life of standard equipment, hours or years	Life of measure, hours or years	Power consumption of standard equipment, kW	Power consumption of measure, kW	Coincidence factor (d)
20	Replace hi-use incandescent lamps with CFLs upon retirement	6,000,000 (FEWE)	3,500 (FEWE)	56 (calc.)	210 (calc.)	0.41 (FEWE)	0.10	15 (FEWE)	0.10	1,000 (FEWE)	10,000 (EPS,RQ)	0.060 (FEWE)	0.016 (EPS,RQ)	0.19
21	Retrofit low-use incandescent lamps with CFLs	12,000,000 (FEWE)	1,800 (FEWE)	49 (calc.)	135 (calc.)	0.44 (FEWE)	0.10	15 (FEWE)	0.10	1,000 (FEWE)	10,000 (EPS,RQ)	0.075 (FEWE)	0.027 (EPS,RQ)	0.19
22	Retrofit hi-use incandescent lamps with CFLs	6,000,000 (FEWE)	3,500 (FEWE)	56 (calc.)	210 (calc.)	[illegible] (FEWE)	0.10	15 (FEWE)	0.10	1,000 (FEWE)	10,000 (EPS,RQ)	0.060 (FEWE)	0.016 (EPS,RQ)	0.19
23	Occupancy sensors	25,000,000 (e)						5 (NYSERDA)			15			
24	Daylighting controls	3,500,000 (f)						60 (NYSERDA)			15			
	STREET LIGHTING (1% of sales)													
25	Retrofit mercury vapor lamps with high-pressure sodium	688,292 (FEWE)	4,015 (PE)	373 (calc.)	843 (calc.)	17 (Grainger)		27 (Grainger)	0.50	20,000 (EPS)	20,000 (EPS)	0.210 (EPS)	0.093 (EPS)	0.95
	INDUSTRY (93% of sales)													
26	Replace 3.5 kW low-use motors with hi-eff motors upon retirement	800,000 (FEWE)	1,800 (FEWE)	5,943 (ACEEE)	6,300 (calc.)	150 (FEWE)		203 (ACEEE)		20 (FEWE)	20	3.5 (FEWE)	3 (ACEEE)	0.30
27	Replace 17.5 kW low-use motors with hi-eff motors upon retirement	225,000 (FEWE)	1,800 (FEWE)	30,111 (ACEEE)	31,500 (calc.)	500 (FEWE)		675 (ACEEE)		20 (FEWE)	20	17.5 (FEWE)	17 (ACEEE)	0.30
28	Replace 120 kW low-use motors with hi-eff motors upon retirement	20,000 (FEWE)	2,400 (FEWE)	280,167 (ACEEE)	288,000 (calc.)	3,480 (ACEEE)		4,680 (ACEEE)		20 (FEWE)	20	120 (FEWE)	117 (ACEEE)	0.30
29	Replace 3.5 kW hi-use motors with hi-eff motors upon retirement	100,000 (FEWE)	5,840 (FEWE)	19,281 (ACEEE)	20,440 (calc.)	150 (FEWE)		203 (ACEEE)		20 (FEWE)	20	3.5 (FEWE)	3 (ACEEE)	0.30
30	Replace 17.5 kW hi-use motors with hi-eff motors upon retirement	50,000 (FEWE)	5,840 (FEWE)	97,694 (ACEEE)	102,200 (calc.)	500 (FEWE)		675 (ACEEE)		20 (FEWE)	20	17.5 (FEWE)	17 (ACEEE)	0.30
31	Replace 120 kW hi-use motors with hi-eff motors upon retirement	5,000 (FEWE)	5,840 (FEWE)	681,741 (ACEEE)	700,800 (calc.)	3,480 (ACEEE)		4,680 (ACEEE)		20 (FEWE)	20	120 (FEWE)	117 (ACEEE)	0.30
32	Replace 3.5 kW low-use motors with hi-eff motors upon rewind	800,000 (FEWE)	2,000 (FEWE)	6,738 (ACEEE)	7,289 (calc.)	84 (h)		203 (ACEEE)		20 (FEWE)	20	3.6 (FEWE)	3 (ACEEE)	0.30
33	Replace 17.5 kW low-use motors with hi-eff motors upon rewind	225,000 (FEWE)	2,000 (FEWE)	34,140 (ACEEE)	36,443 (calc.)	314 (h)		675 (ACEEE)		20 (FEWE)	20	17.9 (FEWE)	17 (ACEEE)	0.30
34	Replace 120 kW low-use motors with hi-eff motors upon rewind	20,000 (FEWE)	3,000 (FEWE)	357,356 (ACEEE)	374,844 (calc.)	2,574 (h)		4,680 (ACEEE)		20 (FEWE)	20	122 (FEWE)	117 (ACEEE)	0.30
35	Replace 3.5 kW hi-use motors with hi-eff motors upon rewind	160,000 (FEWE)	5,840 (FEWE)	19,675 (ACEEE)	21,283 (calc.)	84 (h)		203 (ACEEE)		20 (FEWE)	20	3.6 (FEWE)	3 (ACEEE)	0.30
36	Replace 17.5 kW hi-use motors with hi-eff motors upon rewind	50,000 (FEWE)	5,840 (FEWE)	99,688 (ACEEE)	108,414 (calc.)	314 (h)		675 (ACEEE)		20 (FEWE)	20	17.9 (FEWE)	17 (ACEEE)	0.30
37	Replace 120 kW hi-use motors with hi-eff motors upon rewind	5,000 (FEWE)	5,840 (FEWE)	695,654 (ACEEE)	729,696 (calc.)	2,574 (h)		4,680 (ACEEE)		20 (FEWE)	20	122 (FEWE)	117 (ACEEE)	0.30
38	Retrofit 3.5 kW low-use motors with drive measures	240,000 (FEWE)	1,800 (FEWE)	4,410 (ACEEE)	6,300 (calc.)			2700 (ACEEE)	20		15	3.5	3.15	0.30

Exhibit 17: Technical and Economic Characteristics of Conventional End-Uses and Potential DSM Measures in Poland (cont'd.)

No	Measure	Number of eligible installations	Annual hours of operation	Annual consumption of measure, kWh/yr	Annual consump. of standard equipment, kWh/y	Cost of standard equipment, $	Labor hrs. for standard equipment	Cost of measure, $	Labor hrs. for measure	Life of standard equipment, hours or years	Life of measure, hours or years	Power consumption of standard equipment, kW	Power consumption of measure, kW	Coincidence factor (e)
39	Retrofit 17.5 kW low-use motors with drive measures	67,800 (FEWE)	1,800 (FEWE)	22,080 (ACEEE)	31,500 (calc.)			5,600 (ACEEE)	20		15	17.5	15.75	0.30
40	Retrofit 120 kW low-use motors with drive measures	6,000 (FEWE)	2,400 (FEWE)	201,600 (ACEEE)	288,000 (calc.)			22,000 (ACEEE)	20		15	120	108	0.30
41	Retrofit 3.5 kW hi-use motors with drive measures	48,000 (FEWE)	5,840 (FEWE)	14,308 (ACEEE)	20,440 (calc.)			2700 (ACEEE)	20		15	3.5	3.15	0.30
42	Retrofit 17.5 kW hi-use motors with drive measures	15,000 (FEWE)	5,840 (FEWE)	71,540 (ACEEE)	102,200 (calc.)			5,600 (ACEEE)	20		15	17.5	15.75	0.30
43	Retrofit 120 kW hi-use motors with drive measures	1,500 (FEWE)	5,840 (FEWE)	480,560 (ACEEE)	700,800 (calc.)			22,000 (ACEEE)	20		15	120	108	0.30
44	Motor downsizing	75,000 (ACEEE) (f)	2,771 (f)	83,545 (ACEEE) (f)	72,153 (f)			1000 (f)			20	26 (f)	24.7 (ACEEE)	0.30
45	Replace low-use fluorescent ballasts with efficient core-coil ballasts upon retirement	10,000,000 (FEWE)	1,800 (FEWE)	59 (LBL 2)	64 (calc.)	18 (FEWE)	0.30	23 (LBL 2)	0.30	40,000	45,000 (LBL 2)	0.036 (d)	0.033 (LBL 2)	0.44
46	Replace hi-use fluorescent ballasts with efficient core-coil ballasts upon retirement	5,000,000 (FEWE)	5,840 (FEWE)	510 (LBL 2)	555 (calc.)	26 (FEWE)	0.30	31 (LBL 2)	0.30	40,000	45,000 (LBL 2)	0.095 (LBL 2)	0.087 (LBL 2)	0.44
47	Replace low-use fluorescent lamps & ballasts with T-8 lamps and solid state ballast	10,000,000 (FEWE)	1,800 (FEWE)	44 (LBL 2)	64 (calc.)	18 (FEWE)	0.30	54 (EPS)	0.30	40,000 (LBL 2)	70,000 (LBL 2)	0.036 (d)	0.024 (LBL 2)	0.44
48	Replace hi-use fluorescent lamps & ballasts with T-8 lamps and solid state ballast	5,000,000 (FEWE)	5,840 (FEWE)	377 (LBL 2)	555 (calc.)	26 (FEWE)	0.30	62 (EPS)	0.30	40,000 (LBL 2)	70,000 (LBL 2)	0.095 (LBL 2)	0.065 (LBL 2)	0.44
49	Retrofit low-use fluorescent ballasts with efficient core-coil ballasts	10,000,000 (FEWE)	1,800 (FEWE)	59 (LBL 2)	64 (calc.)	18 (FEWE)	0.30	23 (LBL 2)	0.30	40,000 (LBL 2)	45,000 (LBL 2)	0.036 (d)	0.033 (LBL 2)	0.44
50	Retrofit hi-use fluorescent ballasts with efficient core-coil ballasts	5,000,000 (FEWE)	5,840 (FEWE)	510 (LBL 2)	585 (calc.)	26 (FEWE)	0.30	31 (LBL)	0.30	40,000 (LBL 2)	45,000 (LBL 2)	0.095 (LBL 2)	0.087 (LBL 2)	0.44
51	Retrofit low-use fluorescent lamps & ballasts with T-8 lamps and solid state ballast	10,000,000 (FEWE)	1,800 (FEWE)	44 (LBL 2)	64 (calc.)	18 (FEWE)	0.30	54 (EPS)	0.30	40,000 (LBL 2)	70,000 (LBL 2)	0.036 (d)	0.024 (LBL 2)	0.44
52	Retrofit hi-use fluorescent lamps & ballasts with T-8 lamps and solid state ballast	5,000,000 (FEWE)	5,840 (FEWE)	377 (LBL 2)	555 (calc.)	26 (FEWE)	0.30	62 (EPS)	0.30	40,000 (LBL 2)	70,000 (LBL 2)	0.095 (LBL 2)	0.065 (LBL 2)	0.44
53	Retrofit mercury vapor lamps with hi pressure sodium	700,000 (FEWE)	3,650 (FEWE)	339 (calc.)	767 (calc.)	17 (Grainger)		27 (Grainger)	0.50	20,000 (EPS)	20,000 (EPS)	0.210 (EPS)	0.093 (EPS)	0.44
54	Retrofit high wattage incandescent with metal halide	500,000 (FEWE)	3,650 (FEWE)	339 (calc.)	1,095 (calc.)	5 (Sylvania)		45 (Sylvania)	0.50	2,500 (Sylvania)	8,000 (Sylvania)	0.300 (Sylvania)	0.093 (Sylvania)	0.44
55	Optimize production processes through process monitoring	44,859 (j)		1,104 (Audits)	1,138 (j)	0		5,000 (k)		10		368 (calc.)	365 (calc.)	0.32
56	Industrial maintenance	44,859 (j)		1,081 (Audits)	1,133 (j)	0		7,825 (k)		10		368 (calc.)	369 (calc.)	0.32
57	Interruptible rates	44,859 (j)			1,138 (j)	0		2,500 (l)		15				
58	Time of use rates	10,013 (s)			254 (s)	0		2,500 (l)		15				

Exhibit 17: Technical and Economic Characteristics of Conventional End-Uses and Potential DSM Measures in Poland (cont'd.)

Notes & References:

(calc.)	Value has been calculated from other columns.
(FEWE)	Data provided by FEWE specifically to support this assessment. Some of these values have been adjusted to better match actual electricity sales.
(OTA)	Office of Technology Assessment, "Energy Efficiency Technologies for Central and Eastern Europe" (draft report), 1993.
(EPS)	Electric Power Software Inc., "Technology and Loadshape Information, ver. 1.1", 1992.
(HD)	Price quotation from Home Depot hardware store, Colma, California, January, 1993.
(RG)	Real Goods, "Alternative Energy Sourcebook", 1993.
(LBL1)	Lawrence Berkeley Laboratory, "Energy Efficiency and Household Electric Appliances in Developing and Newly Industrialized Countries", 1990.
(LBL2)	Lawrence Berkeley Laboratory, "Technology Assessment: Energy-Efficient Commercial Lighting", 1989.
(NYSERDA)	New York State Energy Research and Development Authority, "The Potential for Electricity Conservation in New York State", 1989.
(ACEEE)	American Council for an Energy Efficient Economy, "Energy Efficient Motor Systems", 1992.
(IPE)	Institute of Power Engineering, "Badanie poboru mocy i zuzycia energii elektrycznej w grupach odbiorcow finalnych" (Survey of Electric Power Consumption by Groups of End-users), 1993.
(Audits)	Values based on a review of 27 industrial audits conducted in Eastern Europe under USAID's Emergency Energy Program for Eastern and Central Europe.
(Sylvania)	Sylvania Large Lamp Price Schedule 91-1-1.
(Grainger)	Grainger Net Wholesale Catalog, 1992.
(a)	Coincidence factors are calculated as total end-use load at system peak hour for the season (see Chapter 2) divided by total installed end-use power capacity.
(b)	Calculated assuming that half of the total efficiency improvement results from more efficient (lower kW) compressors and motors.
(c)	It is assumed high wattage bulbs represent 24% of all high use bulbs.
(d)	It is assumed these lamps/fixtures have the same losses as the high use fixtures in percentage terms.
(e)	The NYSERDA report estimates that occupancy sensors can save 50% of lighting energy in 15% of lighting installations. Assuming an energy intensity of 30 kWh/m2-yr, there are 25,000,000 m2 of eligible floorspace.
(f)	The NYSERDA report estimates that daylighting saves between 13% to 40% of lighting energy depending on building type. It is assumed for Poland that the most promising 3,500,000 fixtures (10% of all fixtures) account for 20% of total building lighting load, and could reduce total lighting load by 10% if they were retrofit with controls.
(h)	FEWE reported that average rewind costs are about 50% of the cost of a standard motor. The exact proportions used here, which allocate lower percentage costs to smaller motors, is consistent with the FEWE finding, and is based on USAID (Office of Energy and Infrastructure), "Mexico: DSM Assessment" (draft report), 1993.
(i)	Assumes 25% of medium and large motors are candidates for downsizing. Hours of use, energy consumption, and power demand are averages for these motor sizes. Cost based on motor swapping program. This cost includes $300 for installation and $700 to identify participants and arrange motor swapping.
(j)	This corresponds to the number and average annual consumption in MWh of industrial customers (see Chapter 2).
(k)	Average costs estimated to cover $5,000 purchase of simple energy management systems and/or test equipment, consistent with "Audits" above. Industrial maintenance measure also includes present value of $500/year for additional future maintenance costs.
(l)	Costs of meters based on conversation with Cory Pettet, Entergy Inc.
(m)	Cost of conserved energy includes the incremental annual cost of the lamps reported in the table, plus the annualized value for the $75 cost of the fixture/ballast.
(n)	Cost of conserved energy includes the incremental annual cost of the lamps reported in the table, plus the annualized value for the $140 cost of the fixture/ballast.
(p)	Extrapolation of data from the ACEEE reference.
(q)	Cost is in $ per square meter of occupied floor space.
(r)	Cost is in $ per control fixture.
(s)	This corresponds to the number and average annual consumption in MWh for all customers currently on the A11 tariff.

Values without notes or references are assumed.

Global Assumptions:

Real Discount Rate	12.0%
Labor Cost	1.20 $/hr
ASD Applicability	30.0% for small, medium and large motors

Exhibit 18 aggregates the information contained in Exhibit 17 to show the annual energy consumption and total installed capacity for each principal end-use. The information in Exhibit 17 is then used to calculate the cost of saved energy (CSE, the levelized incremental cost of the measure per kilowatt-hour of conserved energy) and the cost of saved capacity (CSC, the levelized incremental cost of the measure per kilowatt of saved generation, transmission, and distribution capacity). Additional details on the candidate measures are given below.

Residential Lighting

Exhibit 15 indicated that the only significant residential lighting source is incandescent lamps. Compact fluorescent lamps (CFLs) have been developed as high-efficiency alternatives to conventional incandescent lighting. The advantages of CFLs include a lifetime about ten times greater and energy consumption about 70 percent less than incandescent bulbs providing the same amount of light. Their disadvantages include the following: CFLs cannot be dimmed, may introduce harmonics, may have a relatively low power factor, and may not fit in all fixtures that previously used incandescent bulbs. Additionally, standard CFLs do not operate properly at low temperatures, some individuals do not like their light quality, some units with lower frequency ballasts hum, and, most importantly, CFLs cost about 15 times more than incandescent bulbs.

A total of four residential lighting measures are considered for Poland representing the use of CFLs in place of both high-use (3,000 hours per year of operation) and low-use (900 hours per year of operation) incandescent lamps on both a retrofit and a replacement basis. Because of the high cost differential between CFLs and incandescent bulbs, the economic attractiveness would be expected to be quite sensitive to the annual hours of operation. In Poland, this sensitivity is tempered somewhat by the observation that, on average, high-use lamps are about one-third less powerful than low-use lamps. Since the cost of CFLs does not vary significantly with power consumption, the CSE nonetheless remains higher for low-use bulbs.

Exhibit 18
Energy Consumption and Installed Wattage by End-Use[1]

End-Use	Annual Energy Consumption (GWh)	% of Total Sector	Total Installed End-Use Capacity (MW)
Residential			
Lighting	14,550	55%	13,250
Refrigerators	5,412	21%	3,288
Water Heaters	1,160	4%	-
Commercial			
Lighting[2]	5,321	54%	2,163
Industrial			
Motors[3]	29,771	58%	11,173
Lighting[4]	4,507	9%	1,132

1 Annual energy consumption and installed wattage calculated from data in Exhibit 17.

2 Does not include 540 GWh of consumption associated with specialty lighting for which measures were not considered.

3 Does not include 5,971 GWh of consumption and 1,440 MW of end-use capacity associated with very large motors (average size 1,200 kW) for which measures were not considered.

4 Does not include 598 GWh of consumption associated with specialty lighting for which measures were not considered.

Residential Refrigeration and Water Heating

There are approximately 91 refrigerators per 100 households in Poland, which are typically manual defrost units. This likely includes refrigerators owned by small, informal commercial establishments, which are nonetheless included in this assessment of residential DSM potential. Refrigerator electricity consumption (and hence savings potential) varies with the volume of the unit. This assessment splits the refrigerator stock into two classes representing those smaller and larger than 170 liters.

Per unit of volume, Polish refrigerators are about half as efficient as the best commercially available. Refrigerator efficiency can be improved through several changes in refrigerator

design and manufacture. According to a report from Lawrence Berkeley Laboratory,[12] the principal methods for increasing refrigerator efficiency for manual defrost units are to use polyurethane foam instead of fiberglass insulation, increase the thickness of the insulation, use a more efficient compressor, and improve door gaskets. Analyses in the United States of options for improving refrigerator efficiency indicate that electricity use can be reduced 30-40 percent with a 15-20 percent increase in manufacturing costs. Lawrence Berkeley Laboratory of the United States is currently conducting further studies of the potential for efficiency improvements in Polish refrigerators.

Four residential refrigeration measures are put forward here corresponding to two levels of efficiency improvement for each of the two size categories. The first level of efficiency improvement represents efficiency comparable to the 1990 U.S. refrigerator average at a 20 percent increase in cost. The second level corresponds the 1993 U.S. standard for new refrigerators at a 40 percent increase in cost. All of these measures would be implemented upon the replacement of existing refrigerators.

Although most hot water needs are met through the district heating system (at least in urban areas), a sizable proportion of households also own storage water heaters. There are about 15 such water heaters per every 100 households in Poland. Although some Polish manufacturers are beginning to offer higher-efficiency water heaters, the measure considered here consists of insulation that can be wrapped around existing water heaters, often called water heater blankets. By reducing heat losses from the water stored in the water heater, these measures reduce the operating time, and hence energy consumption, of electric water heaters.

Commercial Lighting

Both incandescent and fluorescent lighting are found in the commercial sector. As in the residential sector, CFLs can be used in place of incandescent bulbs to reduce energy consumption. Four incandescent lighting end-uses are considered corresponding to the replacement and retrofit of both high-use and low-use bulbs.

There are several possible fluorescent lighting measures. In the United States, delamping or replacement of tubes with high-efficiency fluorescent lamps that slightly reduce lighting

[12] Meyers, S., et al., *Energy Efficiency and Household Electric Appliances in Developing and Newly Industrialized Countries*, LBL-29678, Lawrence Berkeley Laboratory, 1990.

levels are common measures. However, these measures are appropriate only where areas are overlit. As Exhibit 12 indicated, Polish commercial space is typically underlit by U.S. standards. These measures were therefore not considered as part of this assessment.

The use of higher-efficiency ballasts is the primary fluorescent lighting measure proposed for Poland. The standard magnetic, or core-coil, ballasts currently used in Poland can be replaced with either high-efficiency core-coil ballasts or with solid state electronic ballasts. Standard core-coil ballasts often use aluminum wiring, while high-efficiency versions utilize copper wiring and better ferromagnetic materials that produce about a 10 percent improvement in efficiency.[13] Electronic ballasts, on the other hand, consume power at 50 Hz. but operate the lamps at 20 to 30 kHz. These ballasts generally reduce flicker and improve lamp/ballast system efficacy (lumens/watt of power) by 20 to 25 percent.

These fluorescent lighting measures entail the exchange of ballasts, which provides an opportunity to upgrade to more efficient lamps requiring specially adapted fixtures. A common high-efficiency fluorescent tube light that does not result in lower illumination levels is the T-8. These lamps are designed to be used as part of a dedicated electronic ballast system. T-8s are characterized by a smaller diameter, which allows the lamp plasma to be irradiated with lower losses, as well as more efficient phosphor coatings. An electronic ballast for standard fluorescent tubes can be expected to cost around US $15 more than a standard core-coil ballast and yield 20 to 25 percent greater efficacy. For an additional US $20 over the cost of the standard electronic ballast, one can purchase a T-8 system that would boost efficacy by another 20 percent or so.

Eight fluorescent lighting measures are put forward here, representing both retrofit and replacement options for high-use and low-use lamps. One set of these options involves the exchange of high-efficiency core-coil ballasts for standard ballasts, while the other exchanges standard fluorescent fixtures with T-8 systems.

Besides measures for lighting efficiency improvements, two measures have been included for daylighting controls. Occupancy sensors can turn lights on and off using sonic, motion, or heat sensors to detect whether a room is occupied. Daylighting controls regulate illumination levels so that artificial lighting is used only to augment natural lighting to maintain desired illumination levels within the building.

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[13] Lawrence Berkeley Laboratory, *Technology Assessment: Energy Efficient Commercial Lighting*, LBL-27032, Berkeley, California, 1989.

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Industrial Motors

Given the widespread use of motors (especially large motors) in Polish industry, motor measures can provide substantial energy savings. There are four principal ways in which motor performance can be improved:

- *Efficiency improvements.* Motors can be manufactured with improved cooling fan designs to reduce windage losses; larger cross sections, thinner laminates, and special steel alloys for stators and rotors to reduce magnetic losses; better ball bearings to reduce friction losses; and larger gauge conductors to reduce I^2R losses.

- *Improved control.* Standard induction AC motors operate at essentially fixed speeds, even though loads vary in many motor applications. A variety of technologies can be used to better match motor speed with load. Electronic adjustable speed drives (ASDs) have emerged as one of the most flexible technologies for motor control. ASDs typically use AC-DC-AC inverters to vary the frequency or AC supplied to the motor and thereby vary motor speed.

- *Motor downsizing.* Many motors are installed with capacities far in excess of that required by the load. Underloaded motors operate at lower efficiency. FEWE estimates that about 30 percent of motors in Poland are oversized.

- *High-efficiency drive applications.* By improving the efficiency of such drive rotating equipment as pumps and compressors, overall drive system energy consumption can be reduced. Better controls, seals, bearings, and belt and lubrication systems can contribute to high application efficiency. In addition, there is often room for selecting better pump and compressor technologies to match user needs.

A total of 19 motor measures were identified, including 12 for motor efficiency improvements and 1 for motor downsizing. Measures for improved control (principally ASDs) and high-efficiency drive applications were combined into 6 drive measures.

Motor efficiency and drive measures were defined for both high- and low-use motors in the small, medium and large classes described in Exhibit 10. Drive measures were considered on a retrofit basis only, whereas efficiency measures were defined for both replacement upon retirement and replacement upon rewind (according to FEWE, motors are typically rewound in Poland about five times before they are replaced). Average consumption values for both the measures and the standard equipment are based on experience in the United States with motors of similar sizes. The potential energy savings per motor may not be much greater in

Poland. This is because over the years, U.S. motors became less efficient due to lower electricity costs and competitive market forces that reduced capital costs. In the communist world, these market forces did not exist and motors retained higher relative efficiency (e.g., through the use of larger-diameter conductors and magnets). The motor downsizing program assumes that existing motors are switched among enterprises, or within individual enterprises, to yield better utilization of total motor capacity and to avoid additional expenditures on the purchase of new motors.

Very large motors (i.e., 500 kW and larger) were not considered as candidates for motor measures pending further investigation of the costs and benefits of such measures. Because there are so few motors in this size class in the United States and Western Europe, there is little experience with measures targetting these motors. Potential efficiency gains may become negligible for motors of this size. ASDs are commercially available for motors of this size. For example, General Electric and Toshiba produce ASDs for 1,200 kW (approximately 1,600 hp) motors which range in cost between US $150,000 and $250,000 installed. Some mines and district heating companies encountered during the course of this study are considering adding ASDs to their pump and compressor motors in this size class. However, the costs and potential savings associated with ASD applications on this scale are highly site-specific and engineering-intensive relative to smaller motors.

If the further work demonstrates widespread feasibility and cost-effectiveness of measures for motors of this size, these motors could be a potentially significant source of electricity savings.

Industrial Lighting

The industrial sector covers the widest range of lighting technologies, including incandescent, fluorescent, and mercury vapor. Other lighting types are found in the sector, but are not considered as candidates for DSM measures because they are already sufficiently efficient or there are limited opportunities for exchanging them.

Eight fluorescent lighting measures are considered here; they are virtually identical to those put forward for the commercial sector. Measures are also proposed to retrofit mercury vapor lights with high-pressure sodium, and to retrofit high-wattage incandescents with metal halide lamps. Mercury vapor lights are typically used for lighting large exterior and interior areas such as service yards, factories, and warehouses. They generally offer the lowest efficacy of all high-intensity discharge lamps. High-pressure sodium lights have been developed for similar applications, but typically offer far higher efficacy.

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Incandescent lamps (including quartz) are available in sizes up to 1,000 W. Some of these lamps may be used in large-area lighting applications where color rendering is more important. Metal halide lamps can approach the color rendering of incandescent lamps, and do so with much higher efficacy.

Other Industrial Measures

Four other measures are considered for the industrial sector: production process optimization, industrial facility maintenance, interruptible rate programs, and time-of-use (TOU) rates. Although the Tariff Study proposes specific TOU rates, this analysis concentrates on the potential load impacts of those rates.

As part of USAID's Emergency Energy Program for Eastern and Central Europe, energy audits were conducted of industrial facilities in 8 countries, including Poland. The audited firms represented a comprehensive cross-section of industries and covered all forms of energy, including electricity. These audits identified two principal electricity saving measures.

- *Process optimization measures.* Most industrial facilities in Eastern Europe lack modern instrumentation and monitoring equipment. Many processes are operated solely on the basis of operator experience and without the benefit of real-time information on process status or operating parameters. This is understandable, since the previous economic system valued gross production rather than economic efficiency and optimization; instrumentation that could help optimize processes was an unnecessary expense. Therefore, the first measure involves the installation of instrumentation, monitoring, and low-cost control systems that can be used to optimize production processes using economic criteria.

  The audits estimated that simply providing operators with such information and capability would typically save 3 percent of total plant electricity consumption. Here it has been assumed that these savings are achieved with an investment of US $5,000. Measure impacts and costs are based on the average industrial consumer, including the 90 percent of industrial consumers who represent only 20 percent of industrial consumption. The application of this measure has not been limited to the largest consumers in order to preserve the access of all consumers, large and small, to DSM

programs. Consequently, costs reflect the installation of simple instrumentation for the average (i.e., smaller) industrial consumer.[14]

- *Improved maintenance measures.* Similarly, incentives were also previously insufficient to encourage a level of maintenance justified under current economic conditions. The audits revealed that simple maintenance, such as the proper lubrication of motors and machinery, repair of compressor leaks, frequent cleaning of filters and screens, and replacement of door gaskets and curtains, could reduce electricity consumption by 5 percent on average. As with the process optimization measure, costs have been taken to reflect the large number of smaller companies that would be included in the program to implement these measures ($5,000 initially and an additional $500/year thereafter).

Rate measures are generally very cost effective for peak clipping and load shifting. Two rate programs are considered: time-of-use (TOU) tariffs in which consumers pay different electricity rates depending on the time of day or season, and interruptible rates, in which the consumer pays lower rates on the condition that the utility can call up the consumer on short notice and request a reduction in demand of a pre-determined amount for a specified period. The total amount of interruption per year, season, or day can be capped by mutual agreement between the consumer and the utility; failure by the consumer to provide the agreed demand reductions will usually result in financial penalties.

Interruptible rates have not previously been implemented in Poland. It is assumed that this measure would be available to all industrial consumers, so that the costs and impacts of the measures are gauged relative to the average industrial consumer. TOU rates, on the other hand, have been used extensively in Poland on a voluntary basis. However, the Tariff Study has recommended that one of the existing flat rate industrial tariff classes, A11, be converted to a TOU structure. It is therefore assumed that this measure is applied only to consumers in that class, since all other industrial consumers are already within the type of rate structure recommended for that class by the Tariff Study. The average A11 consumer is smaller than the overall industrial average, with annual consumption of 254 MWh and an average weekday peak demand of only 50 kW. What these consumers lack in size they make up in numbers; A11 customers represent approximately 10,000 (22%) of all industrial consumers.

[14] The average industrial consumer is characterized by an annual consumption of 1,138 MWh and an average weekday peak demand of about 215 kW.

Both of these measures require the installation of a meter, which for the TOU rates can tally consumption during different rate periods, and for the interruptible rates can verify consumer compliance with the interruption call. These meters may cost only a few hundred dollars. In addition, the costs of simple controls suitable for these smaller industrial consumers have been included. Low-cost controls such as timers can help participants adjust consumption patterns under these rate programs or reschedule production as needed. This instrumentation differs from that identified in the process optimization measure in that it targets the timing of energy consumption rather than the overall efficiency or level of consumption. The feasibility of this approach is enhanced by the fact that the system peak periods occur in the evening and do not coincide with industrial peaks. A total cost of US $2,500 per customer has been attributed to these measures.

The impacts of these rate programs depend upon the attractiveness of the incentives offered by the utility through tariff concessions. The Electric Power Research Institute in the United States estimates that on a national level, TOU programs will reduce peak system demand by 3.7 percent and total annual consumption by 0.35 percent by the year 2000.[15] This takes into account that many utilities do not currently offer TOU rate programs in the U.S., and even in those that do, only a fraction of industrial consumers may sign up. It is conservatively assumed that in Poland, TOU rates for small industrial consumers and low-cost investment would result in demand savings of 7 percent at the time of system peak (which differs from the industrial peak time) and annual energy savings of 2 percent per participant. If more sophisticated (and expensive) controls were to be installed, such as energy management systems often found in larger industrial plants, savings could might increase considerably. These savings, however, would not likely be justified in light of the relatively meager savings possible with consumers of this size. The savings assumed here are commensurate with the costs of the measures.

For the interruptible programs, it is assumed that average participant demand is reduced by 30 percent at the time of system peak, and that half of the energy lost as a result is regained by scaling up operations in the subsequent period. These load impacts are consistent with TOU rate experience elsewhere.

[15] EPRI, *Impact of Demand Side Management on Future Customer Electricity Demand: An Update*, 1990.

Street Lighting

FEWE estimates that about half of all street lights use mercury vapor lamps. Mercury vapor lighting was discussed in the section above on industrial lighting. The same measure described for the industrial sector, retrofitting mercury vapor lights with high-pressure sodium, is also proposed here for street lighting.

3.3 SCREENING DSM MEASURES

All of the above measures are technically feasible, though not necessarily economically justified. By screening these measures in terms of whether they can save electricity for less than the cost of generating and distributing it, the most promising measures can be selected as a basis for subsequent program design and a more detailed assessment of DSM potential in Poland. Economically justified measures are a necessary condition for viable programs.

The Screening Methodology

Measures are screened by comparing the measure's cost of saved energy (CSE) and cost of saved capacity (CSC) with avoided energy and capacity costs. The CSE is defined as the annualized incremental cost of the measure relative to the cost of standard equipment, divided by the annual kilowatt-hour savings. The CSC is defined as the annualized incremental cost of the measure relative to the cost of standard equipment, divided by the peak kilowatt power reduction. These values have been calculated using the technical and economic characteristics of the measures and standard equipment presented in Exhibit 17.

Because the economic parameters are stated in economic rather than financial terms, the results of the screening analysis provide little indication of whether these measures would be of interest to the utilities or consumers. Economic viability suggests only that it is *possible* to design incentives that are financially attractive without compromising the principal objective of least-cost planning. The incentives actually provided to encourage the implementation of these measures within the context of a DSM program will depend upon factors besides the border prices of the technologies as they are reported here; these include such factors as taxes, subsidies, and other incentive payments. These, in turn, will depend upon the regulatory framework and tariffs that are ultimately adopted in Poland. As explained in Section 1.3, economic analysis is also important because economic justification is a necessary condition for program adoption, as well as a precursor to the financial analysis of program viability.

This screening analysis does not aim to capture all of the costs and benefits of each measure. Costs, for example, do not include the administrative expenses that would be incurred in building and marketing DSM programs based on these measures. Capacity- and energy-saving benefits are assessed separately. Measures pass the screening if they pass on the basis of at least one of these tests. Measures that marginally fail both criteria separately could conceivably pass if capacity and energy benefits were considered simultaneously. This screening analysis aims only to narrow the list of possible measures to the most promising ones, and not to identify a final list of programs.

Because environmental costs are a potentially important consideration, they have been included as part of the avoided energy cost. The derivation of environmental costs is described in Section 4.1. Average avoided energy and generation capacity costs are taken from the preliminary long-run marginal cost analysis presented in the draft Tariff Study. Avoided generation costs are based, somewhat coincidentally, on either a new gas-fired combustion turbine peaking plant or the repowering costs required to rehabilitate existing coal-fired power plants in Poland (these costs work out to be roughly identical; see the discussion in Section 4.3). Because most industrial electricity is consumed at the high-voltage level, avoided capacity costs for industrial measures do not include T&D costs below the high-voltage level. Residential and commercial measures, on the other hand, are assessed against capacity costs, which include T&D costs down through the low-voltage level. Because of the uncertainty in T&D costs reported in the draft Tariff Study, this analysis has adopted more conservative values based on experience elsewhere. Avoided costs are summarized in Exhibit 19 by customer class.

Exhibit 19
Avoided Electricity Costs

Energy (all customer classes):

US $0.027/kWh (average avoided energy cost from the draft Tariff Study) + US $0.021/kWh (environmental cost from Section 4.1) =
US $0.048/kWh (rounded)

Capacity (industrial consumers):

US $67/coincident kW-yr (draft Tariff Study generation cost of $54/kW/year plus estimate of $11/kW/year for HV T&D.)

Capacity (commercial and residential consumers):

US $119/coincident kW-yr (industrial capacity cost given above plus estimate of $42/kW/year for LV and MV T&D.)

Screening Results

The CSE and CSC for each measure are shown in Exhibit 20 along with the physical energy and capacity savings that would be expected if each measure were applied to every eligible end-use device currently in use. Rate programs were not evaluated because they are not amenable to this type of screening analysis, but they are included as DSM programs in Chapter 4.

Measures with a CSE below the avoided energy cost (including environmental costs) were listed along with their total potential savings in ascending cost order to yield an energy conservation supply curve. Upon reviewing Exhibit 20, it was found that there were no measures which passed on a CSC basis that did not also pass on a CSE basis. Therefore, only the energy conservation supply curve is presented (see Exhibit 21).

Many measures with CSEs below the avoided energy cost are mutually exclusive. For example, measures to improve refrigerator efficiency to average 1990 U.S. levels and to improve it to 1993 U.S. standards cannot be implemented simultaneously; the latter would supersede the former. Similarly, if both retrofit and replacement versions of a particular measure passed, replacements would be a subset of the retrofits. To avoid double counting of energy savings, the following rule was adopted to determine which measure would be listed: if two mutually exclusive measures have a CSE below the avoided energy cost, the one that offers quicker implementation would be selected. For example, retrofit measures would be selected over replacement measures since retrofit measures would not have to wait for standard equipment retirement. If both measures could be implemented with the same speed, the one with the lower CSE is selected. For example, in the refrigerator case, the measure corresponding to 1990 U.S. average performance is cheaper and thus is selected over the 1993 U.S. standards.

Exhibit 20: Energy and Capacity Savings Potential

No.	Measure	Cost of Saved Energy	Energy Savings Potential	Cost of Saved Capacity	Capacity Savings Potential
	RESIDENTIAL (22% of sales)				
1	Replace small refigerators (approx. 150 l) upon retirement with 1990 US average	$0.020 per kWh	557 GWh	$245 per kW	46 MW
2	Replace small refigerators (approx. 150 l) upon retirement with 1993 US standard	$0.030 per kWh	760 GWh	$630 per kW	36 MW
3	Replace large refigerators (approx. 230 l) upon retirement with 1990 US average	$0.021 per kWh	1,498 GWh	$211 per kW	148 MW
4	Replace large refigerators (approx. 230 l) upon retirement with 1993 US standard	$0.030 per kWh	2,041 GWh	$542 per kW	115 MW
5	Wrap water heaters	$0.024 per kWh	116 GWh	NA	NA
6	Replace low-use incandescent lamps with CFLs upon retirement	$0.041 per kWh	7,632 GWh	$135 per kW	2,290 MW
7	Replace hi-use incandescent lamps with CFLs upon retirement	$0.036 per kWh	2,850 GWh	$401 per kW	257 MW
8	Retrofit low-use incandescent lamps with CFLs	$0.043 per kWh	7,632 GWh	$142 per kW	2,290 MW
9	Retrofit hi-use incandescent lamps with CFLs	$0.038 per kWh	2,850 GWh	$419 per kW	257 MW
10	Replace hi-use, hi-wattage incandescent lamps with CFLs	$0.024 per kWh	954 GWh	$271 per kW	86 MW
	COMMERCIAL (10% of sales)				
11	Replace low-use fluorescent ballasts with efficient core-coil ballasts upon retirement	$0.120 per kWh	62 GWh	$1,138 per kW	6 MW
12	Replace hi-use fluorescent ballasts with efficient core-coil ballasts upon retirement	$0.025 per kWh	133 GWh	$455 per kW	7 MW
13	Replace low-use fluorescent lamps & ballasts with T-8 lamps and solid state ballast	$0.204 per kWh	246 GWh	$1,936 per kW	26 MW
14	Replace hi-use fluorescent lamps & ballasts with T-8 lamps and solid state ballast	$0.036 per kWh	532 GWh	$668 per kW	29 MW
15	Retrofit low-use fluorescent ballasts with efficient core-coil ballasts	$0.453 per kWh	62 GWh	$4,294 per kW	6 MW
16	Retrofit hi-use fluorescent ballasts with efficient core-coil ballasts	$0.103 per kWh	133 GWh	$1,900 per kW	7 MW
17	Retrofit low-use fluorescent lamps & ballasts with T-8 lamps and solid state ballast	$0.291 per kWh	246 GWh	$2,761 per kW	26 MW
18	Retrofit hi-use fluorescent lamps & ballasts with T-8 lamps and solid state ballast	$0.061 per kWh	532 GWh	$1,125 per kW	29 MW
19	Replace low-use incandescent lamps with CFLs upon retirement	$0.032 per kWh	1,037 GWh	$300 per kW	109 MW
20	Replace hi-use incandescent lamps with CFLs upon retirement	$0.029 per kWh	924 GWh	$537 per kW	50 MW
21	Retrofit low-use incandescent lamps with CFLs	$0.033 per kWh	1,037 GWh	$315 per kW	109 MW
22	Retrofit hi-use incandescent lamps with CFLs	$0.031 per kWh	924 GWh	$564 per kW	50 MW
23	Occupancy sensors	$0.042 per kWh	440 GWh (e)	NA	NA
24	Daylighting controls	$0.053 per kWh	587 GWh (f)	NA	NA

Exhibit 20: Energy and Capacity Savings Potential (cont'd.)

No.	Measure	Cost of Saved Energy	Energy Savings Potential	Cost of Saved Capacity	Capacity Savings Potential
	STREET LIGHTING (1% of sales)				
25	Retrofit mercury vapor lamps with high-pressure sodium	$0.025 per kWh (m)	314 GWh	$107 per kW	74 MW
	INDUSTRY (53% of sales)				
26	Replace 3.5 kW low-use motors with hi-eff. motors upon retirement	$0.020 per kWh	266 GWh	$118 per kW	48 MW
27	Replace 17.5 kW low-use motors with hi-eff. motors upon retirement	$0.017 per kWh	312 GWh	$101 per kW	52 MW
28	Replace 120 kW low-use motors with hi-eff. motors upon retirement	$0.021 per kWh	157 GWh	$164 per kW	20 MW
29	Replace 3.5 kW hi-use motors with hi-eff. motors upon retirement	$0.006 per kWh	185 GWh	$118 per kW	10 MW
30	Replace 17.5 kW hi-use motors with hi-eff. motors upon retirement	$0.005 per kWh	225 GWh	$101 per kW	12 MW
31	Replace 120 kW hi-use motors with hi-eff. motors upon retirement	$0.006 per kWh	95 GWh	$164 per kW	5 MW
32	Replace 3.5 kW low-use motors with hi-eff. motors upon rewind	$0.029 per kWh	441 GWh	$196 per kW	85 MW
33	Replace 17.5 kW low-use motors with hi-eff. motors upon rewind	$0.021 per kWh	518 GWh	$143 per kW	76 MW
34	Replace 120 kW low-use motors with hi-eff. motors upon rewind	$0.016 per kWh	350 GWh	$165 per kW	34 MW
35	Replace 3.5 kW hi-use motors with hi-eff. motors upon rewind	$0.010 per kWh	257 GWh	$196 per kW	13 MW
36	Replace 17.5 kW hi-use motors with hi-eff. motors upon rewind	$0.007 per kWh	336 GWh	$143 per kW	17 MW
37	Replace 120 kW hi-use motors with hi-eff. motors upon rewind	$0.006 per kWh	170 GWh	$165 per kW	9 MW
38	Retrofit 3.5 kW low-use motors with drive measures	$0.212 per kWh	454 GWh	$3,809 per kW	25 MW
39	Retrofit 17.5 kW low-use motors with drive measures	$0.067 per kWh	636 GWh	$1,573 per kW	35 MW
40	Retrofit 120 kW low-use motors with drive measures	$0.037 per kWh	518 GWh	$896 per kW	22 MW
41	Retrofit 3.5 kW hi-use motors with drive measures	$0.065 per kWh	294 GWh	$3,809 per kW	5 MW
42	Retrofit 17.5 kW hi-use motors with drive measures	$0.027 per kWh	460 GWh	$1,573 per kW	8 MW
43	Retrofit 120 kW hi-use motors with drive measures	$0.015 per kWh	315 GWh	$896 per kW	5 MW
44	Motor downsizing	0.037 per kWh	271 GWh	$343 per kW	29 MW

Exhibit 20: Energy and Capacity Savings Potential (cont'd.)

No.	Measure	Cost of Saved Energy	Energy Savings Potential	Cost of Saved Capacity	Capacity Savings Potential
45	Replace low-use fluorescent ballasts with efficient core-coil ballasts upon retirement	$0.120 per kWh	51 GWh	$492 per kW	13 MW
46	Replace hi-use fluorescent ballasts with efficient core-coil ballasts upon retirement	$0.017 per kWh	222 GWh	$225 per kW	17 MW
47	Replace low-use fluorescent lamps & ballasts with T-8 lamps and solid state ballast	$0.204 per kWh	205 GWh	$836 per kW	50 MW
48	Replace hi-use fluorescent lamps & ballasts with T-8 lamps and solid state ballast	$0.022 per kWh	888 GWh	$289 per kW	67 MW
49	Retrofit low-use fluorescent ballasts with efficient core-coil ballasts	$0.453 per kWh	51 GWh	$1,854 per kW	13 MW
50	Retrofit hi-use fluorescent ballasts with efficient core-coil ballasts	$0.062 per kWh	222 GWh	$829 per kW	17 MW
51	Retrofit low-use fluorescent lamps & ballasts with T-8 lamps and solid state ballast	$0.291 per kWh	205 GWh	$1,192 per kW	50 MW
52	Retrofit hi-use fluorescent lamps & ballasts with T-8 lamps and solid state ballast	$0.040 per kWh	888 GWh	$537 per kW	67 MW
53	Retrofit mercury vapor lamps with hi pressure sodium	$0.027 per kWh (m)	299 GWh	$227 per kW	36 MW
54	Retrofit high wattage incandescent with metal halide	$0.046 per kWh (n)	373 GWh	$383 per kW	46 MW
55	Optimize production processes through process monitoring	$0.026	1,531 GWh	$119 per kW	334 MW
56	Industrial maintenance	$0.024	2,552 GWh	$223 per kW	278 MW
57	Interruptible rates	NA	NA	NA	NA
58	Time of use rates	NA	NA	NA	NA

Exhibit 21 depicts the energy conservation supply curve derived from this analysis. Out of 58 measures initially identified, 25 measures pass the screening test (the two rate measures are not counted among the 25 since they were not included in the screening analysis). If all of these measures were implemented for all eligible customers or end-use devices, the energy savings would total 25,400 GWh, or 26.4 percent of 1991 total domestic electricity sales. This is referred to as the economic DSM potential, as opposed to the achievable potential, which takes into account the program costs and market penetration rates of the measures. The achievable potential is assessed in Chapter 4. Screening analyses carried out on a regional basis elsewhere have suggested economic potentials on the order of 25 percent to 40 percent of total consumption.[16]

Exhibit 22 summarizes the composition of current consumption by sector and end-use, as well as the contribution of DSM measures in each of these sectors and end-uses to total savings potential. The residential and industrial sectors offer the greatest potential savings. The following chapter shows, however, that when administrative costs and expected participation rates are taken into account, the industrial sector emerges as the leading sector in terms of achievable DSM potential.

[16] New York State Energy Research and Development Authority, *The Potential for Electricity Conservation in New York State*, Report No. 89-12, Albany, NY, 1989.

Exhibit 21: Energy Conservation Supply Curve for Poland

	Measure	Cost of Saved Energy	Savings
1	Replace 17.5 kW hi-use motors with hi-eff. motors upon rewind	$0.007 per kWh	336 GWh
2	Replace 120 kW hi-use motors with hi-eff. motors upon rewind	$0.008 per kWh	170 GWh
3	Replace 3.5 kW hi-use motors with hi-eff. motors upon rewind	$0.010 per kWh	257 GWh
4	Retrofit 120 kW hi-use motors with ASDs	$0.013 per kWh	368 GWh
5	Replace 120 kW low-use motors with hi-eff. motors upon rewind	$0.016 per kWh	350 GWh
6	Replace small refigerators (approx. 150 l) upon retirement with 1990 US average	$0.020 per kWh	557 GWh
7	Replace large refigerators (approx. 230 l) upon retirement with 1990 US average	$0.021 per kWh	1,496 GWh
8	Replace 17.5 kW low-use motors with hi-eff. motors upon rewind	$0.021 per kWh	518 GWh
9	Retrofit 17.5 kW hi-use motors with ASDs	$0.023 per kWh	537 GWh
10	Wrap water heaters	$0.024 per kWh	116 GWh
11	Industrial maintenance	$0.024 per kWh	2,552 GWh
12	Retrofit mercury vapor streetlights with high pressure sodium	$0.025 per kWh	314 GWh
13	Optimize production processes through process monitoring	$0.026 per kWh	1,531 GWh
14	Retrofit industrial mercury vapor lights with high pressure sodium	$0.027 per kWh	299 GWh
15	Replace 3.5 kW low-use motors with high efficiency motors upon rewind	$0.029 per kWh	441 GWh
16	Retrofit hi-use commercial incandescent lamps with CFLs	$0.031 per kWh	924 GWh
17	Retrofit 120 kW low-use motors with ASDs	$0.032 per kWh	605 GWh
18	Retrofit low-use commercial incandescent lamps with CFLs	$0.033 per kWh	1,037 GWh
19	Replace hi-use comm. fluorescent lamps & ballasts with T-8 systems upon retirement	$0.036 per kWh	532 GWh
20	Motor downsizing	$0.037 per kWh	271 GWh
21	Retrofit hi-use residential incandescent bulbs with CFLs	$0.038 per kWh	2,850 GWh
22	Retrofit hi-use industrial fluorescent lamps & ballasts with T-8 systems	$0.040 per kWh	888 GWh
23	Occupancy sensors	$0.042 per kWh	440 GWh
24	Retrofit low-use residential incandescent lamps with CFLs upon retirement	$0.043 per kWh	7,632 GWh
25	Retrofit high wattage industrial incandescent lamps with metal halide	$0.046 per kWh	378 GWh
		Total	25400 GWh

Industrial rate programs have not been included in this screening analysis.

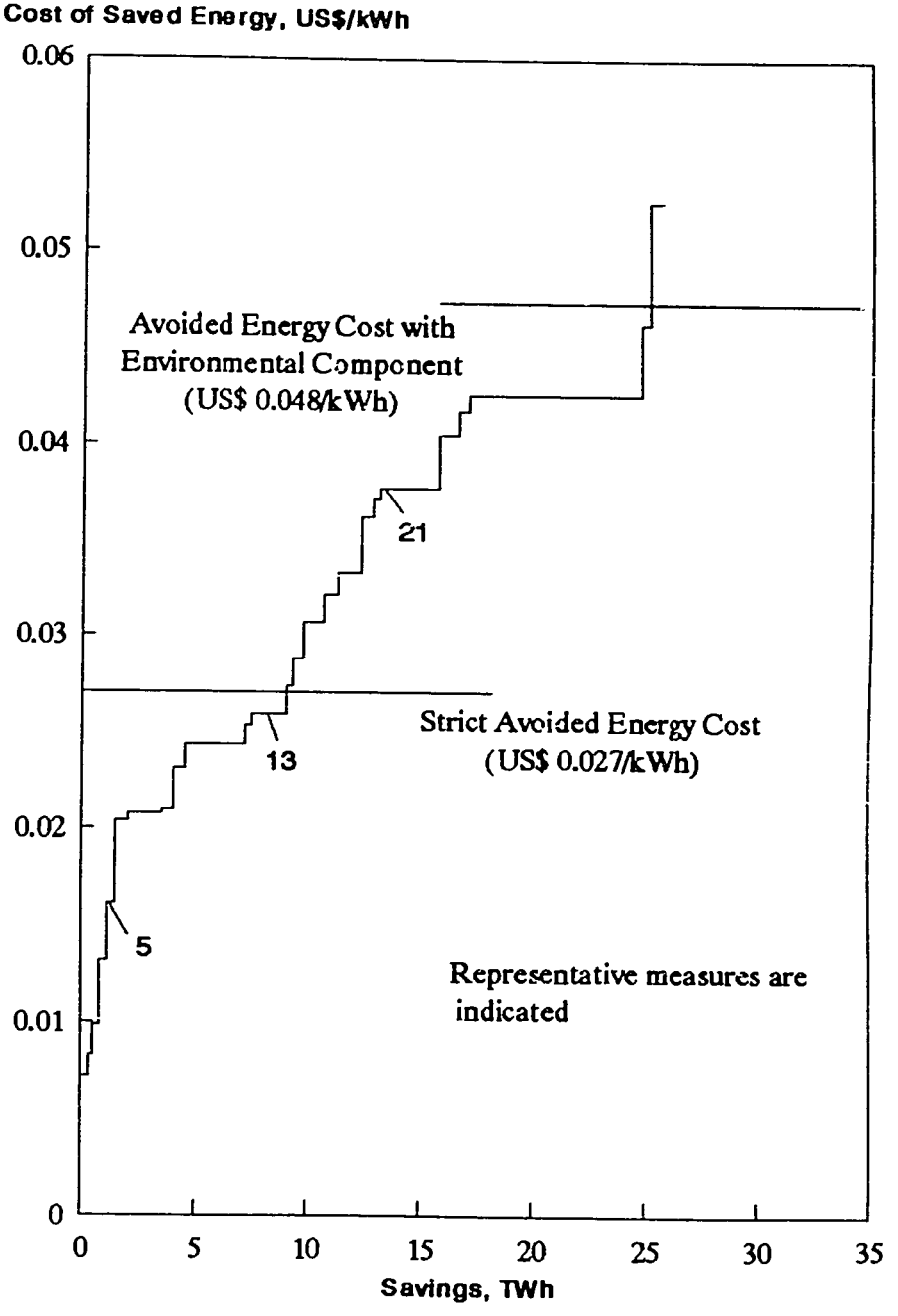
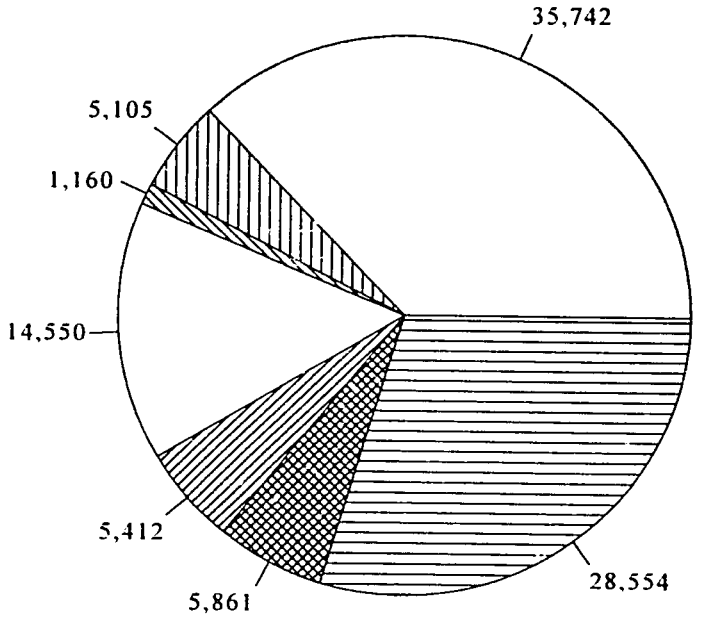
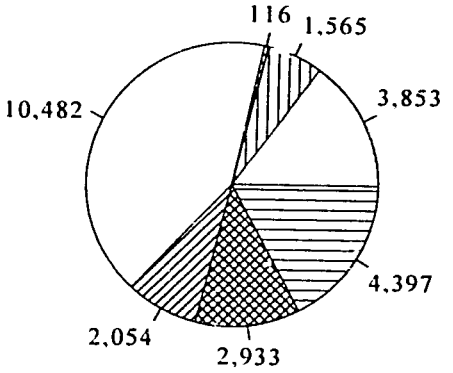


Exhibit 22
Sectoral and End-Use Composition of Total Consumption and Savings Potential



Contribution to Total Consumption (GWh)



Contribution to Savings Potential (GWh)

Ind. Motors | Ind. Lighting | Res. Water Heater | Res. Lighting | Res. Refrig. | Comm. Lighting | Other

CHAPTER 4: THE BENEFITS AND COSTS OF SELECTED DSM PROGRAMS

Chapter 3 identified economically justified DSM measures that could be used to meet Poland's load shape objectives. The potential savings resulting from these measures were also estimated. However, DSM measures cannot install themselves at the customers' premises; their economic potential will not be realized unless steps are taken to market and implement these measures. This chapter identifies DSM programs that would result from packaging the measures with marketing, delivery, and evaluation mechanisms.

The programs described here are used to illustrate the possible scope and impacts of a comprehensive DSM program in Poland. Additional program design studies and pilot program results may point to alternative program formulation. Although specific program marketing and delivery strategies (and, therefore, estimates of program costs and benefits) may change as more information on Polish consumers becomes available, the programs proposed here provide a prelimary assessment of DSM potential and a starting point for further program design efforts.

An important aspect of the following assessment of DSM programs in Poland is that the operation and impacts of the programs are limited to six years (1995 to 2000) which is a fairly short time period. For example, many other regional DSM assessments have typically run for fifteen years. The emphasis in this report on immediate project possibilities, rather than long-term strategic potential, highlights options currently available to Polish energy planners and suitable for multilateral development bank financing. Since this is a conservative approach which does not provide a comprehensive evaluation of the long-term potential of DSM in Poland, the cumulative potential impact of DSM in Poland is understated. As utilities and customers become familiar with the operations and benefits of DSM programs, administrative costs will come down and participation rates will go up, increasing the potential impact of DSM as an electric resource in Poland into the next century.

The programs' benefits and costs are analyzed using DSManager. This sophisticated demand-side planning tool is used to economically evaluate potential DSM programs, taking into account the impediments to the full adoption of the DSM measures as well as the overhead costs associated with program implementation. Because of the uncertainty surrounding some of the values used to calculate program costs and benefits, a sensitivity analysis was also conducted on key parameters to determine whether these results hold over the range of possible parameter values.

4.1 THE ASSESSMENT METHODOLOGY

In general, the assessment of DSM programs compares program benefits, such as reduced capacity and generation requirements, with the costs of marketing, purchasing, and installing the DSM technologies, and administering the programs. Four groups of parties are involved: utilities, customers who take part in the program, ratepayers, and society at large. All of these parties may incur both benefits and costs. Section 1.3 of this report described how DSM programs may be assessed from each of these perspectives. The assessment in this chapter considers only the societal perspective, which is presented here in terms of economic (as opposed to financial) analysis.

The DSManager Approach

DSM programs change the way customers use energy. DSManager traces these changes through the energy system to determine, for example, how the amount of electricity generation changes over time in response to changes in consumption patterns. Using input values that describe how these changes affect costs, DSManager translates these physical measures into monetary terms, and ultimately into costs and benefits.

DSManager represents changes in consumer demand patterns by comparing the end-use load shape of an average target customer before enrollment in a DSM program with the customer's load shape after the DSM measure is in place. A TOU rate program, for example, may shift a customer's total consumption away from system peak periods; although the customer's load shape would change, total energy consumption may remain unchanged. More efficient lighting, on the other hand, may leave the shape of the customer's end-use load curve for lighting unchanged, but reduce the customer total lighting energy consumption, so that the load shape shifts downward.

The end-use load shapes in Poland "before" DSM were shown in Chapter 2. The "after" load shapes for all programs except industrial drives and industrial tariffs entail only a change in energy consumption and not the load shapes. Therefore, "after" load shapes in these cases are simply scaled down from the "before" shape to reflect the higher efficiency of the end-use technology adopted under the program. The energy and capacity savings resulting from these efficiency improvements were noted in Exhibit 20. "After" load shapes for drive and tariff programs involve changes in the shape of the "before" load curve; these are discussed later in this chapter.

Changes in customer load shapes are aggregated by summing over all participants to determine the hourly changes in the utility system load shape. Changes in system load shapes are in turn used to calculate the hour-by-hour production cost savings and the coincident demand reductions and avoided capacity savings. System load data were taken from 1991 hourly system data provided by PPGC, and preliminary avoided energy and generation capacity costs were taken from the draft Tariff Study. Environmental costs are also included in this economic assessment; these costs are derived in the next section.

Avoided capacity expenditures include generation, transmission, and distribution investments foregone as a result of the DSM program. In each year of the analysis, capacity credit benefits are attributed to the DSM program for each coincident kW reduction. Capacity credits are equal to the present value of the change in revenue requirements due to deferring capital for that year. The hourly system demands are an important input into DSManager, because the coincidence of demand (kW) reductions is determined by the interaction between the system load shape and the impacts of DSM programs represented by end-use load shapes.

Program costs are similarly tracked and aggregated. These costs include the direct cost of the technology and its installation, as well as overhead costs related to program management, design, marketing, and evaluation. Evaluation is necessary to determine the size and reliability of the demand-side resources for future system planning and for issuing performance payments or other impact-based incentives.

If a measure is shown to be less costly economically than the system avoided cost, it does not guarantee that the program based on that measure will likewise find economic justification. For example, high fixed administrative costs spread over only a few participants could cause the program to be rejected despite the economic soundness of the measure upon which the program is based. DSManager therefore calculates a benefit-cost ratio for each program to determine its economic viability. This ratio is simply the ratio of the present value of program benefits to the present value of program costs.[16] Programs that pass the benefit-cost test are then considered part of the achievable DSM potential.

[16] Present values are calculated using a 12 percent real discount rate, reflecting the high opportunity costs of capital in a rapidly evolving economy such as Poland's. This value is typically used by multilateral development banks when conducting an economic assessment of projects in Poland.

The Derivation of Environmental Costs

The ratio of DSM benefits to costs in Poland could be substantially underestimated if the environmental benefits of DSM are omitted from the benefit-cost analysis. This is particularly true in the case of Poland, which relies nearly entirely on coal for electricity production with little pollution control; much of this coal has a high sulfur content that can be especially damaging to the environment and human health.

A number of countries, most notably Germany and the United States, are attempting to internalize the environmental benefits and costs of electricity production by quantifying these values and formally integrating them into the resource acquisition process. Multilateral banks are starting to incorporate environmental costs in the appraisal of new projects to address environmental assessment requirements.

Some methodologies used to quantify environmental externalities are based on the cost of pollution control equipment that would be required to mitigate damaging environmental impacts. Other approaches attempt to quantify the cost of those impacts in terms of damage to the environment and to public health, and the costs to society in terms of environmental remediation and/or lost productivity and health costs. In both cases, environmental externality costs estimated to date are generic values, not directly related to the circumstances of a specific geographic situation. These analyses draw heavily on sophisticated health risk methodologies. These various approaches can be combined to capture a range of values that can be used to conduct various sensitivity tests in DSM benefit/cost assessments. No valuation at all would set the lower end of the range to zero.

Two estimates, one developed in Germany and another in the United States, provide a tentative basis for testing the possible impact of internalizing environmental externalities on power sector resource acquisition in Poland. Both are based on the cost of pollution control equipment to mitigate stack emissions from power plants. This is particularly appropriate since a large portion of power sector borrowing requirements in Poland has been earmarked for environmental controls necessary to meet environmental regulations. These two estimates are contrasted with a third estimate based on environmental damage values. None of the estimates examined attempted to internalize environmentally related socio-economic externalities such as job displacement, which can occur when certain industries are forced to internalize environmental costs and contract as a result.

Establishing an Upper Bound. The OKO-Institut of Germany has attempted to monetize emissions based on German control costs.[17] Using a total fuel cycle cost model, TEMIS, an analysis was conducted of the pollution abatement costs in (formerly West) Germany based on the costs of required emission control measures for SO_2, NO_2, and particulates.[18] Because these estimates include costs for both stationary sources and automobiles weighted by the relative contribution of these sources to total emissions, these estimates may over- or under-state the average costs for fixed-source control technology alone. Nonetheless, these are some of the most readily available estimates for energy-sector externalities in a country in close geographic proximity to Poland.

As Exhibit 23 shows, the estimates from the German study were combined with data on emissions in Poland in 1990[19] to arrive at a US$/kWh estimate of selected environmental externality costs. The total value for Poland using the OKO-Institut methodology is US $0.042/kWh -- more than the present retail cost of energy production in Poland. Consequently, this value was selected as the upper bound for our environmental externalities sensitivity tests.

Exhibit 23 also puts forward numbers based on a damage valuation scheme. A study by Pace University in the United States suggests a "starting point" valuation of US $0.078/kWh when adapted to the Polish emissions profile. Although this figure could have been used as the upper bound for the sensitivity tests, it was not. This is because the damage costs are likely to differ substantially between Poland and the United States, and because it results in a valuation of over two and one-half times the retail price of energy in Poland. Values of this magnitude would likely eclipse other benefits and costs calculated in this DSM benefit/cost study.

Establishing a Mid-Point Value. With zero used as a lower bound in the environmental externalities sensitivity tests, a mid-range value was based on an environmental externalities valuation developed in the State of New York using the cost-of-

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[17] See Hohmeyer, O. and R.L. Ottinger (eds.), "Incorporating Externalities in Least-Cost Planning: The Use of Control Costs, Standards, and Multi-Attribute Approaches," in *External Environmental Costs of Electric Power*, Springer-Verlag, 1991.

[18] Costs for CO_2 emissions are also addressed in the OKO study, but this gas is not currently considered a criteria pollutant in Poland.

[19] Central Statistics Office, *Ochrona Srodowiska, 1991 (trans. Environmental Protection, 1991)*, Warsaw, 1991.

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Exhibit 23
Environmental Externalities for Power Generation in Poland

Pollutant	Pace (2) (US$/ton)	New York (3) (US$/ton)	OKO (4) (US$/ton)
SO_2	4,060	832	2,268
NO_2	1,640	1,832	1,814
Particulates	2,380	333	454
	(1) (US$/kWh)	(US$/kWh)	(US$/kWh)
SO_2	0.0599	0.0123	0.0335
NO_2	0.0059	0.0066	0.0065
Particulates	0.0122	0.0017	0.0023
Total	0.0780	0.0206	0.0423

Notes:
(1) US$/ton is converted to US$/kWh using 1990 Polish net generation of 113,545 GWh and 1990 Polish utility emissions (as reported by GUS) of 1,675,960 US tons of SOx, 407,660 US tons of NOx, and 582,450 US tons of particulates.
(2) Pace valuation taken from *Environmental Costs of Electricity*, Pace University Center for Environmental Legal Studies, Oceana Publications, 1990.
(3) New York figures cited in *External Environmental Costs of Electric Power*, op. cit., p. 65.
(4) OKO valuation from *External Environmental Costs of Electric Power*, op. cit., p. 65.

control approach. These values, as noted in Exhibit 23, are based principally on the application of advanced control technology to SO_2 and the application of primarily low-cost technology to NO_2 mitigation. These are the values used formally by the State of New York in its resource acquisition process. When adapted to the Polish emissions profile, the New York valuation results in an environmental externality of US $0.021/kWh (rounded from US $0.206/kWh).

Future Estimates. Poland may wish to examine the valuation of environmental externalities in greater detail. The German figures discussed above, for example, could be revised to correct for mobile sources. Damage cost approaches applicable to Poland could be developed on the basis of further research. Socio-economic externalities could also be factored in, such as job displacement in the coal industry or job growth in the energy

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efficiency industry. The figures used here are illustrative and are used as proxies for a Poland-specific externalities valuation.

4.2 DSM PROGRAMS IN POLAND

Identifying cost-effective measures does not ensure they will be adopted. Experience in numerous countries shows the difficulty in persuading customers to make energy-related technology decisions based on life-cycle operating costs. Sometimes this may be attributed to market distortions, the most important of which may simply be a lack of information. Alternatively, prices may not reflect the true economic costs or benefits of different investment options. Lack of financing may also be an important obstacle. Other reasons have been cited previously in Section 1.2.

Programs combine measures with marketing, delivery, and evaluation mechanisms. Marketing and delivery are particularly important to overcome the obstacles noted above and ensure that demand-side resources are effectively exploited. Program design and marketing, if performed properly, will ensure an effective mix of education, market-based incentives, and applicability of a measure to a customer segment. Delivery or implementation may involve a promotional campaign and/or actual installation of a measure on behalf of a customer. This can be particularly suitable for relatively new technologies with which the customer may not be familiar, such as ASDs. Programs must also be evaluated to provide the utility with essential information on the impact on demand that DSM programs are having in order to account for these impacts in future least-cost plans.

Several DSM measures may be aggregated and delivered within a single program directed towards a particular market segment. Offering customers multiple measures can help meet site-specific applications, minimize program overheads by spreading fixed administrative costs over several measures, maximize market penetration, and minimize the impact on the customer's residential routine, commercial business activities, or industrial production by implementing several measures at once. In some cases, sector-specific DSM measures targeting multiple end-uses have been aggregated together for delivery to a specific customer class. By combining measures in this way, marketing and delivery overheads can be further reduced. For example, lighting, water heating, and refrigeration measures can be delivered as part of a single program to maximize the opportunity to achieve savings when visiting a residential customer site (such as in a door-to-door campaign). However, for the purposes of this benefit/cost assessment, which does not attempt to undertake a detailed program design, measures were aggregated by customer class and end-use only. This reflects a conservative

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assumption that each end-use will incur its own administrative costs. Administrative costs are included at three levels:

- *Customer or measure level.* Within any program, each technology will incur an administrative cost that can be calculated on a per-measure or per-customer basis. The variable costs at the measure level vary widely depending on the technology, type of program, and mix of resources devoted to program design, implementation, and evaluation. In this study, these variable administrative costs were estimated for Poland based on the type of program being evaluated and local labor costs. The specific figures used are discussed below.

- *Program level.* These costs are required to design, market, manage, implement, track and evaluate each program. They are often fixed overheads that are incurred whether the program has 1,000 or 10,000 participants. As with variable costs, we estimated a fixed program overhead based on Polish labor rates and the size and duration of each program. The specific figures used are also discussed below.

- *National level.* Finally, to capture the administrative costs that are incurred in undertaking DSM on a national scale, the assessment also accounts for fixed administrative overhead pertaining to the cost of establishing a DSM group within each of Poland's distribution companies. Each distribution company will require these resources to plan strategically and coordinate DSM programs throughout all sectors within each service territory. These overheads would accrue whether the distribution companies actually deliver the programs or not, and regardless of the number or size of programs they administer. Specific estimates are discussed below.

Estimating Fixed Administrative Overheads

Accounting for fixed administrative costs at both the program and national levels required a "bottom-up" methodology using Polish labor rates. The national overheads could not be allocated to specific programs without adopting a complex set of largely unsubstantiated assumptions; hence, these costs were factored into the overall, nationwide, aggregated benefit/cost analyses performed as a last step in this analysis.

National overhead costs would cover the staff costs of a small DSM group within each utility responsible for DSM planning and program supervision. Exhibit 24 shows these costs. In addition to these "national" overheads, each program includes a set of fixed overheads to cover program design, marketing and evaluation. To account for the varying complexity of

Exhibit 24
Estimated National Administrative Costs

Resources	Number	Rate (US$)	Cost (US$/yr)
Professional Staff	4	5,000/yr	20,000
Administrative Staff	2	2,500/yr	5,000
Office Equipment	-	35,000/5 years	7,000
Miscellaneous	-	5,000/yr	5,000
Total/Distribution Co.	-	-	37,000
Total for Poland	-	-	**555,000**

DSM programs, both low and high cost scenarios were developed for program-specific fixed overheads. The assumptions used to develop these scenarios are as follows:

	Low Cost	High Cost
Relevant Programs	All Residential Programs, All Commercial Programs, Street Lighting and Motor Downsizing	Industrial Motors, Drives, and Rates
Design Costs per program	US$200,000 in the first year	US$250,000 in the first year
Marketing Costs per prgm.	US$75,000/year	US$150,000/year
Evaluation Costs per prgm.	US$75,000/year	US$100,000/year

Design costs include the identification of target consumers and the formulatiion of detailed marketing, implementation, monitoring, and evaluation plans. Marketing costs cover the expense of actually reaching the target consumers. Evaluation costs include the costs of data

acquisition and analysis needed to carry out both process and impact evaluations.[20] Although evaluation costs are expressed on an annual basis, this value takes into account that evaluations may be conducted every two or three years depending on the program. The industrial programs identified as high-cost programs require more extensive customer contact and assistance, as well as provisions to better tailor the measures to individual customer needs.

Separate variable costs are also associated with marketing and evaluation; these variable costs are described under each program. The distinction between fixed and variable costs for marketing and evaluation overheads helps to better estimate overall administrative costs. For example, fixed costs for these activities could be attributed to the personnel needed to carry them out. Variable costs, on the other hand, would be associated with the data collection or site visits necessary to carry out the activity.

Residential Lighting

All residential lighting measures that passed the initial screen described in Chapter 3 were aggregated into a "Residential Lighting Program." The measures included in this program were:

- low-use compact fluorescent lamps
- high-use compact fluorescent lamps.

The program benefit/cost results reflect the participation assumptions made at the measure level, the administrative costs at both the measure and program level, and the load shape impacts of the program based on the magnitude of energy and demand savings for each measure. All the measures included in this program were assessed as retrofit applications. This is in part attributed to the nominal value lost in removing incandescent lamps prematurely, the advantage of enjoying CFL benefits immediately, and the low impact of installation on a customer's daily routine.

Participation. In this program, which begins in 1995 and ends in 2000, low-use compact fluorescents could attract 1 percent of the 1991 base population over the lifetime of the program. (This ratio is defined here as *cumulative final market penetration* in 2000.)

[20] Process evaluations examine how a program was designed and delivered, and how it can be improved to expand participation, reduce costs, and increase benefits. Impact evaluation considers the actual savings associated with the program.

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This penetration is based on an estimate that only 10 percent of the total population of such lamps would even be suitable for compact fluorescents since many applications in Poland have such low usage that CFLs simply are not applicable. Moreover, CFLs will not fit all standard fixtures in Poland, further diminishing market share. While a figure higher than 10 percent could have been chosen in the modeling of this program, 10 percent was selected as a conservative estimate of feasibility/applicability for this measure, yielding a 10 percent *eligible* population. Of the potential 10 percent market, it was assumed that the program would attract 10 percent of the 1991 population of eligible participants. That is, 10 percent of the incandescent fixtures that could be replaced by CFLs would, in fact, be replaced over the six-year life of the program. Cumulative final market penetration is calculated as follows:

> 10% (feasibility/applicability) x 10% (market penetration of 1991 eligible participants over the life of the program) = **1%** (cumulative final penetration in 2000 of the 1991 base population)

The high-use application is at least twice as applicable because these units are more suitable for CFLs given their greater use. As noted in the previous chapter, this makes them more attractive by delivering a greater magnitude of energy and demand savings and accelerating the payback of the measure. Hence, high-use, cumulative final CFL market penetration is the result of:

> 20% (feasibility/applicability) x 10% (market penetration of the 1991 eligible participants over the life of the program) = **2%** (cumulative final market penetration in 2000 expressed as a percentage of the 1991 base population)

These final market penetration figures require two important caveats:

- All cumulative final market penetration estimates, including those which follow in this chapter, will actually be lower when expressed as a percentage of the year 2000 end-use population because of growth in the 1991 base population.

- In the case of measures with a lifetime shorter than that of the program, cumulative final market penetration *will not correspond to the number of fixtures operating in the year 2000.* For measures like these with a lifetime of less than 6 years, fixtures installed in the early years will have already burned out by the year 2000. It is conservatively assumed that there is no automatic re-enrollment in the program. Consequently, the number of fixtures installed

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in 2000 will be less, in these instances, than the cumulative participation over the life of the program.

This is the case, for example, with high-use, residential CFLs. Although cumulative final penetration is calculated above as 2 percent, the number of units in service in 2000 would actually be 1.3 percent of the 1991 base population. This results from subtracting fixtures installed in the first three years of the program because the lifetime of these high-use CFLs is only three years.

This issue only arises for two measures in this chapter, residential and commercial high-use CFLs, because these measures burn out in less than six years. *Unless stated otherwise, cumulative final market penetration in 2000 is synonymous in this chapter with the number of installed units in the year 2000.*

The cumulative final market penetration rates for CFLs are conservative. In the United States, residential lighting programs have achieved between 5 percent and 48 percent market penetration of the *eligible* population with programs of varying lifetimes.[21] One U.S. program achieved a 14 percent market penetration after five years, but this figure is based on the number of households participating, not on the number of *eligible* fixtures retrofitted (the approach used here). A program targeting low-income customers in southern California reached 48 percent of *eligible* customers after seven years compared to the 10 percent over six years assumed here.[22] This type of program, with its emphasis on job creation and helping consumers overcome the high first costs of a measure, may be especially suitable for Poland. Final market penetration, as defined above, is not available for this California program, but it would be far less than 48 percent in this instance. Another U.S. program achieved 38 percent final market penetration at the end of three years, but that penetration was achieved using a leasing approach that was not considered in this rudimentary program design.[23]

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[21] *Electric Utility Conservation Programs: A Review of the Lessons Taught by a Decade of Program Experience*, ACEEE 1990 Summer Study on Energy Efficiency in Buildings (Proceedings), 1990, Vol. 8, pp. 179-205.

[22] *Southern California Edison: Low Income Relamping, The Results Center*, IRT Environment, Inc., Vol. 2, 1992, p. 13.

[23] *Burlington Electric Department: Smartlight, The Results Center*, IRT Environment, Inc., Vol. 3, 1992, p. 14.

Market penetration is often "bell shaped," reaching its maximum mid-way and declining toward the latter part of the program.[24] Exhibit 25 shows data for the residential lighting program, including the total number of new participants in this program over its six-year duration. Throughout this analysis, participants are variously defined as fixtures, units, or customers, depending on the measure.

Exhibit 25
Residential Lighting Program Summary

	1995	1996	1997	1998	1999	2000
Capital Cost (000)*	$464	$1,393	$3,251	$5,254	$6,938	$6,837
Administrative Cost (000)	$815	$1,080	$2,010	$2,475	$2,475	$1,185
New Participants (000)**	155	310	620	775	775	345
Energy Savings (GWh)	19	56	130	209	274	267
Peak Demand Savings (MW)	3	9	22	36	48	48

* Capital costs incurred by current participants and O&M costs incurred by current or previous-year participants. Lighting costs are levelized.

** Participants are defined as lighting fixtures.

Administrative Costs. In addition to the fixed program administrative overheads included in all program assessments, a variable administrative cost specific to residential lighting programs was included. These costs were allocated on a per-fixture basis: $1.00 per fixture for marketing, nothing for implementation, and $2.00 for program evaluation for a total variable overhead cost of $3.00/fixture. Marketing costs were relatively low based on the assumption that this program would deliver these energy services rebates door-to-door at Polish labor rates. There are no implementation costs because customers would install their own lamps. Evaluation costs were higher than marketing costs because trained personnel would need to visit a sample of customer sites to spot check whether lamps have actually

[24] The market penetration for the measures in this program were 5 percent in the first year, 10 percent in the second, 20 percent in the third, 25 percent in the fourth and fifth, and 15 percent in the last, the year 2000. This distribution is a derivative of the "S" shaped, market penetration curve used in modeling market penetration wherein adoption is slow initially, picks up speed at an increasing rate, reaches a maximum rate of adoption, and then slows down as a result of market saturation.

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been installed. All these costs were based on Polish labor rates and are shown in Exhibit 25 together with the fixed program costs.

Load Shape Impacts. The Residential Lighting Program is expected to deliver 267 GWh of energy and 48 MW of peak demand savings in the year 2000 based on the market penetration figures discussed above. Exhibit 17 provided more detailed information on the savings associated with each measure. Given a peak coincident factor of 0.27 for the measures included in this program, a residential lighting program would reduce peak demand in Poland but without significantly changing the system load shape. Hence, this is primarily an energy conservation program. Exhibit 25 shows the year-by-year savings estimated for this program.

Residential Refrigeration

This program combines measures for the replacement of both small and large refrigerators with higher-efficiency models. These measures were modeled as replacements because, unlike incandescent bulbs, removing a standard refrigerator before its useful life is exhausted entails a cost sufficiently high to diminish the cost-effectiveness of a retrofit application.

Participation. Because this is a replacement program, participation was tied directly to the number of customers entering the Polish market for new refrigerators in each year of the program. By assuming a 20-year life for both small and large refrigerators, a simple calculation was made to determine how many units in the existing stock will turn over each year. We assumed that replacing 10 percent of these new units with energy-efficient units would not be technically feasible because, for example, some of the energy-efficient units may not fit in the customer's site because of differences in size or other features. Exhibit 26 shows data for the program, including the annual estimated participation.

The cumulative final market penetration for both measures in this program is 2.7 percent in the year 2000 of the 1991 base population. This figure is based on a 10 percent average yearly penetration of the eligible population (90 percent of the total population) over the life

of the program in an escalating curve that drops down after the program has ended.[25] The final penetration rate was calculated as follows:

Exhibit 26
Residential Refrigeration Program Summary

	1995	1996	1997	1998	1999	2000
Capital Cost (000)*	$710	$710	$1,421	$1,421	$2,131	$2,131
Administrative Cost (000)	$551	$351	$552	$552	$753	$753
New Participants (000)**	27	27	54	54	80	80
Energy Savings (GWh)	5	11	22	33	49	65
Peak Demand Savings (MW)	1	1	3	4	6	8

* Capital costs incurred by current participants and O&M costs incurred by current or previous-year participants.

** Participants are defined as units (refrigerators).

5% (turnover/year) x 90% (feasibility/applicability) x 60% (10% avg annual participation x 6 yrs) = **2.7%** (cumulative final participation in 2000 as a share of the 1991 base population)

This penetration rate is conservative given some of the U.S. and Canadian experience with these programs. For example, several U.S. utilities have achieved penetration of the *eligible* market of anywhere between 9 and 29 percent.[26] The comparable figure in this analysis is at the low end (10 percent). In terms of final market penetration, a Canadian utility achieved a 9.4 percent penetration in a pilot refrigerator buy-back program over two years.[27] (Refrigerators were bought back to ensure that older models were not used as second refrigerators.) A value of 2.7 percent is conservatively used here.

[25] Yearly penetration of 5 percent was estimated for the first and second years, 10 percent in the third and fourth years, and 15 percent in the fifth and sixth years.

[26] *Wisconsin Residential Appliance Efficiency Rebate Programs: A Regulators Perspective*, ACEEE 1990 Summer Study on Energy Efficiency in Buildings (Proceedings), Vol. 8, 1990, pp. 141-149.

[27] *British Columbia Hydro: Power Smart Refrigerator Buy-Back Pilot*, The Results Center, IRT Environment, Inc., Vol. 10, 1992, pp. 6-11.

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Because the lifetime of refrigerators was estimated at 20 years, all energy-efficient refrigerators installed over the lifetime of the program will be operating at the end of the program in the year 2000.

Administrative Costs. In addition to fixed program overheads discussed earlier, the benefit/cost analysis included a variable administrative cost for the refrigeration program: each energy-efficient unit would require $0.50 for marketing, $2.00 for implementation, and $5.00 for evaluation. These costs differ from the residential lighting program because we assumed that marketing would consist of a very low-cost approach such as customer bill stuffers as in the previously mentioned Canadian program.[28] Administrative costs were incurred during implementation because a rebate would be provided through appliance dealers. Polish utilities would also spend resources in working with refrigerator manufacturers and distributors and in managing the rebate program. Evaluation costs would be higher for this program than the previous one because evaluation could require random metering of sample customer sites. This would entail expenditures in the field, both for personnel and hardware. These costs are included with fixed administrative costs in Exhibit 26.

Load Shape Impacts. This program could save 65 GWh in energy and 8 MW in peak demand in the year 2000. Exhibit 17 provided further details on the relative impact of specific measures.

Although these measures have a peak coincident demand of 0.19, the program would reduce slightly system demand, but without significantly changing the shape of the overall load profile in Poland. Consequently, this program is essentially an energy conservation rather than a peak clipping program, "scaling down" the system load curve rather than changing its shape. The annual savings are shown in Exhibit 26.

Residential Water Heating

The "Residential Water Heating Program" evaluated in this study included only one measure: the application of a water heater wrap. Because this is a low-cost technology that complements rather than replaces the existing water heater system, this measure was

[28] Ibid., p. 7.

evaluated as a retrofit application. The program could deliver the technology in a door-to-door energy conservation campaign. This program design sets the groundwork for the participation assumptions.

Participation. As a retrofit program, participation is not constrained by turnover in the existing stock of water heater technologies in Poland. However, as in any program, participation in a door-to-door water heater wrap program can vary markedly depending on the resources devoted to market the technology. Participation in this program would be higher than in the residential lighting or refrigeration programs because of the low cost and simplicity of applying the technology and the effectiveness of door-to-door delivery of energy services to utility customers. In the United States, for example, some utility companies have assumed a 10 percent market penetration rate when planning for similar but more short-lived programs to acquire these DSM resources.[29]

It was conservatively assumed that it would not be feasible to apply wraps to 20 percent of the existing stock of water heaters in Poland. Some units may not be readily accessible, are too small for a water heater wrap application, or are already energy efficient. Ten percent of the remaining (eligible) units would be wrapped over the course of the program, yielding a cumulative final market penetration in 2000 as follows:

> 80% (eligible units) x 10% (market penetration) = **8%** (cumulative final market penetration, expressed as a percentage of 1991 population).

This figure is relatively conservative in relation to comparable figures found in the United States. An extraordinarily successful program in the state of Oregon in the U.S. attained a 91 percent market penetration of eligible households with an energy conservation program targeting numerous end-uses including water heaters.[30] This program enjoyed some unique advantages such as a highly motivated, lightly urbanized customer base pertaining to a utility cooperative -- not an investor-owned power company. For these and other reasons, it would not be prudent to base estimated Polish participation on this particular program.

The distribution of participants over the life of the program is a "bell shaped" distribution as in several previous programs: 5 percent of the cumulative participants entering the program

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[29] *Commonwealth Edison Company Least-Cost Plan*, Appendix to Chapter IV, "Demand Side Planning,' December 1989.

[30] *Hood River Conservation Project*, The Results Center, IRT Environment, Inc., Vol. 12, 1992, p. 13.

in 1995, 10 percent in 1996, 20 percent in 1997, 25 percent in 1998 and 1999, and 15 percent in 2000. Exhibit 27 shows data for the program, including the actual participation used to calculate the energy and demand savings.

Administrative Costs. Variable administrative costs would be incurred both for marketing (US $1.00/unit) and evaluating the program (US $2.00/unit). As mentioned earlier, the marketing costs are based on a door-to-door campaign using existing community organizations at Polish labor rates. Evaluation would entail the same level of expenditure as the residential lighting program since the two programs are similar in some important ways. In each, a low-tech measure is distributed to customers on a broad scale. Also, as in the lighting program, no implementation costs are incurred in installing water heater wraps since this task is left to the customer. Variable and fixed costs by year are shown in Exhibit 27.

Exhibit 27
Residential Water Heater Program Summary

	1995	1996	1997	1998	1999	2000
Capital Cost (000)*	$61	$122	$243	$304	$304	$182
Administrative Cost (000)	$374	$198	$246	$270	$270	$222
New Participants (000)**	8	16	32	40	40	24
Energy Savings (GWh)	1	2	4	7	9	11
Peak Demand Savings (MW)	0	0	1	1	2	2

* Capital costs incurred by current participants and O&M costs incurred by current or previous-year participants.

** Participants are defined as units (water heaters).

Load Shape Impacts. The water heater program is expected to save 11 GWh and 2 MW in the year 2000. Exhibit 17 provided additional details on the costs and savings of the measure. Given a low peak demand coincidence factor of 0.07 for water heating as an end-use in Poland, the program serves primarily to conserve energy by shrinking the utility load shape with little or no impact on its profile. Exhibit 27 shows the yearly savings estimated for this program.

Commercial Lighting

In the United States, commercial lighting has offered numerous opportunities for cost-effective savings. Some of the same technologies used for residential end-uses and screened in Chapter 3 are applicable here, too, such as compact fluorescent lamps. Some more recently commercialized technologies, such as occupancy sensors, have now become cost-competitive for commercial applications and are playing an increasing role in acquiring commercial DSM resources.

The "Commercial Lighting Program" combines a few select but very different technologies that would likely be cost-effective in Poland. The following measures were included in this program:

- low-use compact fluorescent lamps
- high-use compact fluorescent lamps
- occupancy sensors
- high-use T-8 lamps with efficient electronic ballasts.

The first three measures were designed as retrofit applications just as in the residential lighting program. As in that program, the value of waiting for lamps to burn out before replacing them -- and giving up energy savings in the meantime -- does not appear to be economically justified as the screening analysis has shown. There are programmatic reasons for a retrofit design as well, such as the economic efficiency of performing installations all at once rather than piecemeal. This retrofit design is not as appropriate for T-8 lamps, which require the retirement of standard ballasts, a relatively expensive component in relation to associated operational costs and the cost of fluorescent lamps. This measure is included in the program evaluation as a replacement measure, as in the screening exercise.

Participation. For commercial CFL programs in Poland, participation could occur at the rate of 20 percent of the eligible population over the life of the program. These participants would be distributed across the six-year program in a bell-shaped distribution: 5 percent entering during the first year, 10 percent in the second, 20 percent in the third, 25 percent in the fourth and fifth, and 15 percent in the sixth. For the commercial T-8 replacement measure, a technology lifetime of 12 years was assumed, translating into a turnover rate of 8.3 percent per year at an escalating rate: 5 percent in the first and second years, 10 percent in the third and fourth years, and 15 percent in the fifth and sixth years. Since occupancy sensors represent a relatively new technology in Poland, it was estimated

that 1 percent of the eligible 1991 base population in Poland would participate over the life of the program.

In each case, the penetration rates used in evaluating the Commercial Lighting Program assumed that less than 100 percent of the entire population of fixtures would be suitable for the energy-efficiency applications evaluated here. For example, as in residential lighting, CFLs are sometimes not applicable if a lighting application requires very low use, and sometimes the efficient bulbs simply do not fit the fixtures. It was estimated that only 40 percent of the low-use applications would be suitable for CFLs in Poland's commercial sector and 70 percent for high-use.

For T-8s, 80 percent of the base population was assumed to be eligible for T-8 replacements due to the high applicability of these measures. It was also assumed that only 50 percent of the total population of applications would be suitable for occupancy sensors. Many commercial establishments, such as retail enterprises, must remain lit during business hours regardless of whether people are present. Other commercial lighting applications, such as conference rooms, may be used infrequently, and staff are conscientious about turning out the lights when the rooms are not in use.

Final market penetration rates in 2000 as a share of the 1991 base population were calculated as follows:

- *Low-use commercial CFLs:* 40% (feasible/applicable) x 20% (participation rate) = **8%** (cumulative final market penetration)

- *High-use commercial CFLs:* 70% (feasible/applicable) x 20% (participation) = **14%** (cumulative final market penetration)

- *T-8s:* 8.3% (annual turnover of 1991 population) x 80% (feasible/applicable) x 60% (10% average annual market penetration x 6 years) = **4.0%** (cumulative final market penetration)

- *Occupancy sensors:* 50% (feasible/applicable) x 1% (participation) = **0.05%** (cumulative final market penetration).

Data for the Commercial Lighting Program are shown in Exhibit 28.

In the United States, commercial and industrial lighting programs have achieved widely ranging participation rates -- 0.1 percent to 36.7 percent for programs reported -- of the

eligible participants.[31] A California utility even reported a 45 percent market penetration of the *eligible* population.[32] A mid-point value of 20 percent of the eligible population was used in this analysis.

Exhibit 28
Commercial Lighting Program Summary

	1995	1996	1997	1998	1999	2000
Capital Cost (000)*	$328	$888	$2,008	$3,190	$4,261	$4,529
Administrative Cost (000)	$785	$953	$1,756	$2,124	$2,190	$1,454
New Participants (000)**	107	197	394	485	501	321
Energy Savings (GWh)	15	42	97	157	211	225
Peak Demand Savings (MW)	2	7	16	25	34	36

* Capital costs incurred by current participants and O&M costs incurred by current or previous-year participants. Lighting costs are levelized.

** Participants are variously defined as fixtures.

Administrative Costs. Variable administrative costs for commercial lighting are similar to residential lighting except that marketing would be more expensive (US $2.00/fixture) because special attention would have to be paid to each customer site to execute an optimal relamping strategy. Implementation costs are already embedded into the cost of the technologies screened in the previous chapter. Evaluation costs would be the same as those for residential customers ($2.00/fixture). Because occupancy sensors have a very different cost structure from conventional commercial lighting technologies, their administrative costs were calculated on a per customer, not a per-fixture, basis. We estimated that these costs would be $10 each for marketing, implementation and evaluation, for a total of $30/customer. Annual variable and fixed administrative costs for the program are shown in Exhibit 28.

[31] *Lessons Learned: A Review of Utility Experience with Conservation and Load Management Programs for Commercial and Industrial Customers*, New York State Energy Research and Development Authority, April 1990.

[32] *Sacramento Municipal Utility District: Commercial Lighting Installation Program*, The Results Center, IRT Environment, Inc., Vol. 13, 1992, p. 13.

Load Shape Impacts. The Commercial Lighting Program could save Poland 225 GWh in energy and 36 MW in demand in the year 2000, with a 0.19 coincident peak demand. For a detailed look at the relative contribution of each measure, refer to Exhibit 17. The impact on the system would primarily be to conserve energy because the system load profile would not change shape as a result of this program.

Industrial Motors

The "Industrial Motors Program" comprises all industrial high-efficiency motor measures. This program targets mostly replacement applications upon rewind (although low-use 3.5 kW motors are replaced upon retirement). Replacement upon rewind was evaluated based on the incremental costs and benefits of a new, high-efficiency motor over the benefits and costs of a single rewind.

This large program includes eight measures:

- both low- and high-use 3.5 kW high-efficiency motors
- both low- and high-use 17.5 kW high-efficiency motors
- both low- and high-use 120 kW high-efficiency motors.

Participation. Based on information collected by FEWE and experience elsewhere, the average low-use motor is rewound every five years and the average high-use motor every three years, corresponding to a 20 percent annual turnover on low-use motors and 33 percent on high-use motors. Since low-use 3.5 kW motors are candidates only upon retirement, the annual turnover is 5 percent, corresponding to a 20-year lifetime. High-efficiency motors are estimated to be feasible replacements for 90 percent of these. Of the eligible low-use motors, 5 percent are exchanged annually during the first two years of the program, and 10 percent annually for the remaining four years. Of the eligible high-use motors, 5 percent are exchanged annually during the first two years, 10 percent annually during the next two years, and 15 percent annually during the last two years.

Data for the program are shown in Exhibit 29. Cumulative final market penetration rates in 2000 as a percent of the 1991 base population were calculated as follows:

- *Low-use 3.5 kW motors:* 5% (annual turnover) x 90% (feasibility/applicability) x 10% (average annual penetration among eligible motors) x 6 years = **2.7%** (cumulative final market penetration).

Exhibit 29
Industrial Motor Program Summary

	1995	1996	1997	1998	1999	2000
Capital Cost (000)*	$4,354	$4,354	$8,708	$8,708	$9,809	$9,809
Administrative Cost (000)	$960	$710	$1,169	$1,169	$1,232	$1,232
New Participants (000)**	29	29	57	57	61	61
Energy Savings (GWh)	39	78	157	235	318	401
Peak Demand Savings (MW)	6	13	25	38	51	64

* Capital costs incurred by current participants and O&M costs incurred by current or previous year participants.

** Participants are defined as units (motors).

- *Low-use 17.5 kW motors:* 20% (annual turnover) x 70% (feasibility/applicability) x = 10% (average annual penetration among eligible motors) x 6 years = **10.8%** (cumulative final market penetration).

- *Low-use 120 kW motors:* 20% (annual turnover) x 70% (feasibility/applicability) x 10% (average annual penetration) x 6 years = **8.4%** (cumulative final market penetration).

- *High-use 3.5, 17.5, and 120 kW motors:* 33% (annual turnover) x 90% (feasibility/applicability) x 8.3% (average annual turnover) x 6 years = **14.8%** (cumulative final market penetration).

Penetration rates for motor programs implemented in the United States fall in a range from less than 1 percent all the way up to 33 percent, according to one of the few studies undertaken on the subject.[33] Low participation rates have sometimes been attributed in the United States to a number of factors, the most notable being the "inventory" problem. Rewinding a motor can get the plant back in service in 24 to 48 hours. Replacement requires that a motor of the appropriate size, shape, bolt pattern, and type is immediately available. This is not often the case; even an exact motor "off the shelf" may carry a price

[33] *Lessons Learned: A Review of Utility Experience with Conservation and Load Management Programs for Commercial and Industrial Customers*, New York State Energy Research and Development Authority (NYSERDA), April 1990, pp. S-6 to S-8.

premium. Typical delivery time for a new motor over 50 kW is 4 to 20 weeks in the U.S. Other negative factors include unfavorable early customer experiences with high-efficiency motors due to improper sizing and installation, unfamiliarity of customers and dealers with the substantial operating cost savings that efficient motors can provide, diffuse decision-making on motor purchases, or hesitation to shut down production lines to replace a motor. The program considered here avoids this last barrier because all measures were modeled as replacements. The pilot program described in Part 2 of this report addresses these issues to maximize penetration rates.

Administrative Costs. Variable administrative costs for marketing each motor measure to customers are considerably higher than for lighting applications (US $10.00/motor). Customer sites, while fewer in number than in the residential or commercial sectors, would require more one-on-one attention to ensure that the new motors were correctly sized to each specific process. In the case of British Columbia Hydro, a Canadian power company, the utility marketing staff contacts large industrial customers routinely, and a specialist representing the motors program calls on all of the motor vendors and rewind shops regularly to ensure their familiarity with the operation and benefits of the program.[34] A Niagara Mohawk (New York utility) program also emphasized close customer relations in the large industrial segment.[35] Implementation costs have been included in the cost of the measure. Spot metering may be used for evaluation, which would boost the cost (US $6.00/motor) beyond the evaluation cost of other measures such as lighting. Total administrative costs, including fixed program costs, are shown in Exhibit 29 for each year of the program.

Load Shape Impacts. This program is expected to save 401 GWh and 64 MW in the year 2000. The energy savings of each motor type were provided in Exhibit 17. With a coincident demand factor of 0.30, this program could have a significant impact on reducing peak demand in Poland. However, the program would not change the profile of the system hourly demand curve; instead, it would simply reduce it. Savings are also shown in Exhibit 29.

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[34] *British Columbia Hydro: Power Smart High-Efficiency Motors*, The Results Center, Vol. 38, 1992, IRT Environment, Inc., p. 7.

[35] *Lessons Learned*, op. cit, p. 82.

Industrial Drives

Adjustable speed drives are a relatively new technology to many utility customers even in the OECD countries. This places an added burden on adequate program marketing and implementation in Poland. The higher, related costs and limited participation are reflected here in the modeling of ASD applications in Poland.

The five measures aggregated into a program were:

- ASDs and high-efficiency drive applications for low-use 120 kW applications
- ASDs and high-efficiency drive applications for high-use 17.5 and 120 kW applications.

The screening analysis in Chapter 3 indicated that ASDs are too expensive to justify low-use applications in the smaller motor size ranges. These measures were omitted from the program.

Participation. Because drive measures complement rather than replace existing motor technology, all measures in this program were modeled as retrofit applications. As such, participation was not tied to turnover in the motor population. Analysis conducted in the United States suggests that from 20 percent to 40 percent of all industrial motors are suitable for ASD installation.[36] In this analysis, it was assumed that ASD and high efficiency drive applications would be feasible for 30 percent of Polish motors, and that of these, one in six would actually receive a drive measure over the course of the program. Cumulative final penetration in 2000, expressed as a percentage of the 1991 population, is derived as follows:

30% (feasible/applicable) x 17% (cumulative penetration) = **5%** (final market penetration).

There is little documentation on the U.S. experience in ASD program market penetration with which to easily compare our figure, but this value is fairly conservative given the attractive payback of these technologies and some of their load shifting characteristics. Participation was distributed as follows: 5 percent in the first year, 10 percent in the second, 15 percent in the third, 20 percent in the fourth, and 25 percent in the last two years. Data

[36] Nadel, S. et al., *Energy Efficient Motor Systems*, ACEEE, 1992.

for the program, including the total number of participating motors, are shown by year in Exhibit 30.

Exhibit 30
Industrial Drive Program Summary

	1995	1996	1997	1998	1999	2000
Capital Cost (000)*	$631	$1,234	$1,865	$2,490	$3,115	$3,115
Administrative Cost (000)	$511	$272	$284	$295	$306	$306
New Participants**	57	112	169	225	281	281
Energy Savings (GWh)	3	10	20	34	51	68
Peak Demand Savings (MW)	1	2	3	5	8	10

* Capital costs incurred by current participants and O&M costs incurred by current or previous-year participants.

** Participants are variously defined as units (motors).

Administrative Costs. Marketing drive measures in Poland would be a relatively expensive effort on a per-unit basis (US $150/unit), although marketing costs as a percentage of the technology capital cost is low. Because ASDs are a relatively complex technology, technical expertise is required to promote these measures effectively and this promotion must be done at the customer site. These factors escalate the cost of marketing this program relative to other programs.

Because of the complexity of the technology, additional administrative costs of US $40/unit would be associated with implementation, in addition to the actual installation costs included as part of the capital cost of the measure. Evaluation costs would be comparable to the efficient motors program (US $10/unit). Variable plus fixed costs for the entire program by year are available in Exhibit 30.

Load Shape Impacts. A drive program could save Poland 68 GWh and 10 MW in demand in the year 2000. The load reduction resulting from the use of ASDs decreases as motor load increases because the primary purpose of an ASD is to reduce power demand as motor load falls. This analysis assumes that drive measures would yield a 15 percent

reduction in motor peak demand, but would reduce total annual energy consumption by 30 percent. Exhibit 17 indicated the energy savings associated with each measure. Annual savings are summarized in Exhibit 30.

Industrial Motor Downsizing

Motor downsizing is a separate program of its own because of the unique cost and programmatic features of a motor-swap program, the type of program modeled here. Because this program entails swapping existing motors, there are no capital costs associated with the program other than average data collection and installation costs of US $300/motor. While programs like this have not been tried in the United States, the Sao Paulo (Brazil) municipal utility, Companhia Energetica de Sao Paulo, has implemented this type of program, which they call the "Fleximotor" program.

Participation. It is assumed that out of the total industrial customer population of 44,859 in 1991, 50 percent of the customers would be ineligible because either their motors were already properly sized or were too small to be downsized. It is also assumed that 5 percent of the eligible population would, in fact, participate over six years, ending in 2000. This low figure reflects the potential difficulty with implementing this innovative program.

Cumulative final market penetration in 2000 as a percentage of the 1991 population was calculated as:

> 50% (feasible/applicable) x 5% (participation rate) = **2.5%** (cumulative final market penetration)

Program data, including annual participation, are shown in Exhibit 31.

Administrative Costs. Marketing, implementation, and evaluation overheads are estimated to cost US $50.00, $100.00, and $50.00, respectively. The variable plus fixed costs per year for this program are shown in Exhibit 31.

Exhibit 31
Industrial Motor Downsizing Program Summary

	1995	1996	1997	1998	1999	2000
Capital Cost (000)*	$17	$37	$50	$67	$84	$84
Administrative Cost (000)	$361	$172	$184	$195	$206	$206
New Participants**	56	112	168	224	280	280
Energy Savings (GWh)	1	1	2	4	5	7
Peak Demand Savings (MW)	0	0	0	1	1	1

* Capital costs incurred by current participants and O&M costs incurred by current or previous-year participants.

** Participants are variously defined as customers.

Load Shape Impacts. This program would achieve 7 GWh in energy and 1 MW in demand savings in the year 2000 with a peak coincident factor of 0.30. Load impacts for individual installations were shown in Exhibit 17. This program would primarily be an energy conservation program. Annual savings are also summarized in Exhibit 31.

Optimization of Industrial Operations

Improved instrumentation and monitoring to optimize operations and better maintenance practices can add up to substantial savings at low cost. This program entails two measures designed to address both process controls and maintenance as discussed in Chapter 3. This type of program, though offering attractive savings often at low cost, requires special attention for evaluating the savings actually achieved.

Participation. In the case of both measures, 20 percent of the existing industrial population might already be operating at high levels of energy efficiency or might otherwise be unsuitable for this type of program. Of the remaining population, the analysis assumes that 5 percent of all facilities would participate with respect to each measure. Cumulative final market penetration in the year 2000 as a percentage of the 1991 population of industries would be, therefore (for both measures):

80% (feasible/applicable) x (5% + 5%) (participation rate for each measure) = **8%** (final penetration)

Five percent of the total cumulative participation would occur in the first years of the program, 10 percent in the next year, 20 percent in the third year, 25 percent in the fourth and fifth years, and 15 percent in the final year, consistent with the bell-shaped participation distribution associated with other programs.

While the market penetrations of specific measures such as these have not necessarily been evaluated in the United States, data do exist on the penetration of some broader programs that include measures such as energy management systems and low-cost measures. One such program achieved 8.3 percent participation of eligible large customers and a final market penetration of 2.75 percent after three years.[37] This figure may not be appropriate for Poland, however, because this particular program required fairly extensive intrusion on the customer site for the purposes of detailed data collection, and customers were required to submit formal proposals to the utility.

Program data, including annual participation, are shown in Exhibit 32.

Exhibit 32
Industrial Operations Optimization Program

	1995	1996	1997	1998	1999	2000
Capital Cost (000)*	$945	$1,925	$3,904	$5,018	$5,248	$3,587
Administrative Cost (000)	$860	$966	$1,686	$2,042	$2,044	$1,326
New Participants**	180	358	718	896	897	538
Energy Savings (GWh)	9	26	60	103	146	171
Peak Demand Savings (MW)	1	4	10	17	24	28

* Capital costs incurred by current participants and O&M costs incurred by current or previous-year participants.

** Participants are variously defined as customers.

[37] *Bonneville Power Administration: Energy Savings Plan*, The Results Center, IRT Environment, Inc., Vol. 18, 1992, pp. 6 and 13.

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Administrative Costs. The marketing of this program could be relatively inexpensive, employing low-cost techniques such as advertisements in industry trade journals. Although implementation would be entirely the responsibility of the customer, there would be the cost of an audit to identify the appropriate measures for a particular customer. Evaluation would be relatively expensive in order to carefully check whether recommended improvements have been implemented by participants, the amount of energy actually saved, and whether or not improved maintenance practices persist. We estimate these variable costs at approximately US $2,000/participant. The cost of developing the capability to carry out this program is reflected in the relatively high fixed administrative costs for the program. Total variable plus fixed administrative costs for this program are shown in Exhibit 32.

Load Shape Impacts. This program could save Poland 171 GWh in energy and 28 MW in demand savings in the year 2000 with a coincident peak demand of 0.32. Specific energy savings by measure can be found in Exhibit 17. Overall, this program would represent an energy conservation program in Poland. Energy and demand savings estimates are also included in Exhibit 32.

Industrial Lighting

The "Industrial Lighting Program" was modeled primarily as a retrofit program using technologies that were not applied in the residential or commercial programs. The exception is T-8 lamps, which were modeled as replacement measures for the same reasons used in designing the commercial lighting program earlier in this section. Three measures were included in this program:

- high-pressure sodium retrofits
- metal halide retrofits
- T-8 lamps and electronic ballast retrofits.

Participation. Different penetration rates were assumed for each measure. Mercury vapor lamps require a ballast and are typically used for high-use applications in which color rendition is not important. Since high-pressure sodium lamps offer similar characteristics, the feasibility of replacing mercury vapor lamps with high-pressure sodium was estimated to be 90 percent (a small allowance of 10 percent was made to account for mercury vapor lamps that may be seldom used). Metal halide lamps are not nearly as applicable when used to replace incandescent lamps because they may not fit or the existing incandescent lamps

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may be seldom used. Therefore, a much lower feasibility of 40 percent is assumed for this measure. The same is true, though, to a lesser extent, with T-8 lamps with electronic ballasts; 60 percent feasibility is estimated for T-8s. In all these retrofit programs, participation is expected to reach 25 percent of eligible customers over the life of the program. The participation was modeled in an escalating distribution: 5 percent in the first year, 15 percent in the second year, and 20 percent in the third, fourth, fifth and sixth years. Cumulative final market penetration for these measures in the year 2000 (as a percent of the 1991 base population) is:

- *High-pressure sodium*: 90% (feasible/applicable) x 25% (participation rate) = **22.4%** (final market penetration).

- *Metal halide:* 40% (feasible/applicable) x 25% (participation rate) = **10%** (final market penetration).

- *T-8s with electronic ballast:* 60% (feasible/applicable) x 25% (annual turnover) = **15%** (final market penetration).

As mentioned in the commercial lighting section, utilities in the United States have achieved anywhere from 0.5 percent to 45 percent participation of the *eligible* population across multiple measures within any single program. Program lifetimes have also varied greatly. The estimates used here are towards the lower end of the range. Program data, including annual participation for this program, are shown in Exhibit 33.

Administration. Industrial lighting variable administrative costs were estimated exactly as those used in the commercial lighting program (US $2.00/fixture for marketing and US $2.00 for evaluation). Total annual variable plus fixed costs are shown in Exhibit 33.

Load Impacts. An industrial lighting program could achieve 256 GWh in energy and 44 MW in demand savings in the year 2000 with a 0.44 coincidence factor. This is the highest coincidence factor among all the industrial measures. Energy savings at the measure level were shown in Exhibit 17. The program would serve primarily to meet utility energy conservation load shape objectives. Exhibit 33 also shows the annual savings for both energy and demand.

Exhibit 33
Industrial Lighting Program Summary

	1995	1996	1997	1998	1999	2000
Capital Cost (000)*	$288	$1,152	$2,303	$3,455	$4,607	$5,758
Administrative Cost (000)	$542	$725	$916	$916	$916	$916
New Participants (000)**	48	144	192	192	192	192
Energy Savings (GWh)	13	51	103	154	205	256
Peak Demand Savings (MW)	2	9	18	26	35	44

* Capital costs incurred by current participants and O&M costs incurred by current or previous-year participants. Lighting costs are levelized.
** Participants are defined as fixtures.

Industrial Rates

The "Industrial Rates Program" considered here includes two measures: time-of-use (TOU) and interruptible and curtailable (I&C) rates. The first is typically modeled as a load shifting measure providing a small amount (2 percent of customer consumption) of energy savings. Utilities typically use the second measure to clip the system peak. The energy savings usually associated with this measure are even smaller, occurring only during the interruption of industrial operations.

Participation. Participation estimates for each of the rate measures are based on different assumptions. Interruptible rate programs will be feasible for only a minority of industrial enterprises; it is assumed that about one-third of industrial customers can accomodate interruptible rates. Of these customers, it is further assumed that one-quarter ultimately enroll in the program. Cumulative participation therefore reaches 8.2 percent of all industrial consumers. Because of the potential reluctance of firms to enroll in such a program, it has been assumed that 5 percent of participating firms enroll in the first year, 10 percent in the second, 15 percent in the third, 20 percent in the fourth, and 25 percent in the fifth and sixth years.

Whereas the interuptible program has been specified as open to all industrial consumers, the TOU program has been limited to only those consumers currently on the A11 tariff. TOU rates are already in place for all other industrial consumers with the exception of those very small consumers in class B1. This analysis follows the recommendation of the Tariff Study

that A11 consumers be converted from a flat rate to a TOU rate. Conversion to this mandatory rate structure would follow the same phasing as for the interruptible program, i.e., 5 percent of all A11 consumers in the first year, 10 percent in the second year, and so on.

Administration. The relatively high fixed administrative costs for this program cover the extra design and marketing efforts required for this program. In addition, a variable administrative cost of US $500 per participant has been included to cover the cost of helping customers develop strategies to maximize their benefits under these programs. Since these programs target smaller industrial consumers and rely on low-cost control strategies, it is not expected that this level of administration will be sufficient to achieve the assumed participation and impact.

Exhibit 34
Industrial Rates Program Summary

	1995	1996	1997	1998	1999	2000
Capital Cost (000)*	$1,463	$2,925	$4,388	$5,850	$7,313	$7,339
Administrative Cost (000)	$843	$935	$1,278	$1,620	$1,963	$1,969
New Participants**	685	1,370	2,055	2,740	3,425	3,438
Energy Savings (GWh)	3	9	18	29	44	59
Peak Demand Savings (MW)	13	39	77	129	194	258

* Capital costs incurred by current participants and O&M costs incurred by current or previous-year participants.

** Participants are defined as customers.

Load Impacts. Poland could save 59 GWh in energy and 258 MW in demand in the year 2000 if these rate programs began in 1995. These results are shown in Exhibit 34. The demand savings represent about 8 percent of the assumed incremental system demand growth of 3,253 MW between 1995 and 2000, and 47 percent of the total demand savings estimated for the entire Poland DSM program. These demand savings are reported for the winter system peak, and hence are greater than the savings (in absolute terms) that will occur at the summer system peak (savings were modelled as a percentage of industrial load, which is higher in the winter).

This innovative rates component could clearly meet some of Poland's peak clipping and load shifting objectives because, although Poland appears to have excess capacity in meeting system peak demand in the winter, much of this capacity is unavailable in the summer. Although there appears to be sufficient winter capacity to meet growing demand during the season system peak, these tariff programs can help obviate capacity additions intended to add to summer capacity.

Street Lighting

Retrofitting mercury vapor with high-pressure sodium lamps was the only measure included in the "Street Lighting Program." This measure is likely a top candidate in targeting this public lighting market segment in Poland.

Participation. As a retrofit program unconstrained by the turnover rate in the existing stock of technologies in a market segment under government control, this program should achieve high rates of participation. It is assumed that 50 percent of the street lights in Poland could be retrofitted with high-pressure sodium lamps and that 100 percent of the lamps would be retrofitted over the six-year lifetime of the program in a bell-shaped distribution: 5 percent in the first year, 10 percent in the second, 20 percent in the third, 25 percent in the fourth and fifth, and 15 percent in the last. Cumulative final market penetration in 2000 as a percentage of the 1991 population was calculated as follows:

> 50% (feasible/applicable) x 100% (participation rate) = **50%** (final market penetration)

Program data, including annual participation, are shown in Exhibit 35.

Administration. Variable costs were assumed to be US $1.00 per fixture for marketing because only the government and municipalities would need to be targeted. There would be no administrative cost associated with implementation because each jurisdiction would itself install the measures (the capital costs reported in Exhibit 17 include a component for installation). Finally, US $1.00 per fixture was assumed for evaluation, which should require a fairly straightforward check of local government records and some spot checking in the field. Total annual administrative costs are also shown in Exhibit 35.

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Exhibit 35
Street Lighting Program Summary

	1995	1996	1997	1998	1999	2000
Capital Cost (000)*	$184	$551	$1,285	$2,203	$3,121	$3,672
Administrative Cost (000)	$383	$217	$284	$317	$317	$250
New Participants (000)**	17	33	67	84	84	50
Energy Savings (GWh)	10	31	73	125	177	208
Peak Demand Savings (MW)	3	8	19	32	45	53

* Capital costs incurred by current participants and O&M costs incurred by current or previous-year participants. Lighting costs are levelized.
** Participants are defined as fixtures.

Load Impacts. This program could save Poland 208 GWh in energy and 53 MW in demand in the year 2000 with the extraordinarily high coincidence factor of 0.95. Impacts at the measure level were given in Exhibit 17. This program would primarily be an energy conservation program. The annual savings are also shown in Exhibit 35.

4.3 ASSESSMENT RESULTS

Exhibit 36 aggregates the costs and savings associated with all of the preceding programs. National administrative costs are also included in this exhibit.

Peak demand savings for the nationally aggregated program exceed planned capacity additions (a 120 MW gas-fired combustion turbine to be added in each of the years 1996, 1997, and 1999). However, as pointed out in Section 1.2, substantial rehabilitation of existing power plants will also be undertaken during the 1993-2000 time period. While only 360 MW of new capacity are expected by 2000, 2,865 MW of existing capacity are to be rehabilitated. PPGC estimates the costs of rehabilitation at US $800/kW. Assuming that half of this is attributable to environmental controls (which are already accounted for in the

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environmental externality cost), the annualized cost of the remaining rehabilitation expenditure is equivalent to the combustion turbine component of capacity costs.[38]

Exhibit 36
National DSM Program Summary

	1995	1996	1997	1998	1999	2000
Capital Cost (000)*	$9,445	$15,287	$29,426	$37,960	$46,930	$47,043
Administrative Cost (000)	$6,984	$6,579	$10,363	$11,975	$12,672	$9,819
Energy Savings (GWh)	117	317	685	1,088	1,489	1,738
Peak Demand Savings (MW)	32	92	193	314	447	554

* Capital costs incurred by current participants and O&M costs incurred by current or previous-year participants. Lighting costs are levelized.

Using DSManager, TRC and Societal Cost tests were conducted for each individual program, each program cluster, and all programs together. The assessment of individual programs does not include any fixed administrative overheads. The assessment of the aggregated program (or plan) includes not only the direct costs of the individual programs but also the fixed administrative costs that accrue to the aggregated program. The assessment of all programs takes into account direct program costs, fixed overheads for each program cluster, and the national program overheads that pertain to all programs. The assessment was built up in this way because there was no clear way to allocate fixed overheads to individual programs.

The TRC and Societal Cost tests used the same cost inputs, expressed in border price terms, except that the Societal Cost Test also included environmental costs, whereas the TRC did not. The TRC results therefore represent economic analysis assuming zero environmental costs, and the Societal Cost Test represents economic analysis assuming mid-point environmental costs.

Exhibit 37 summarizes the benefit/cost ratios for each program and plan, as well as the net benefits, the cost of saved energy, and the cost of saved capacity. These results show that

[38] The generation capacity component of the avoided costs given in Exhibit 17 (and as calculated in the Tariff Study) is approximately US $56/coincident kW-yr, while the 25-year annualized cost of a US $400/kW investment with a 12 percent discount rate is US $58/kW-yr.

Exhibit 37: Summary of Assessment Results

	NAME	DESCRIPTION	Benefit/Cost Ratio		Net Benefits ($)		Levelized Cost ($/kWh)		Levelized Cost ($/kW)	
			TRC Test	Societal Cost Test	TRC Test	Societal Cost Test	TRC Test	Societal Cost Test	TRC Test	Societal Cost Test
1	ALL_PLAN	All Programs Aggregation – PLAN	1.87	2.66	159,141	304,503	0.0260	0.0260	78.92	78.92
2	R_REFRGP	Residential Refrigeration – PLAN	1.97	2.90	6,695	13,077	0.0223	0.0223	184.27	184.27
3	I_PROCSP	Industrial Process – PLAN	1.20	1.88	3,687	16,523	0.0302	0.0302	182.52	182.52
4	S_LIGHTP	Street Lighting – PLAN	2.10	3.20	21,374	42,645	0.0187	0.0187	73.42	73.42
5	C_LIGHTP	Commercial Lighting – PLAN	1.60	2.29	11,134	23,984	0.0297	0.0297	183.10	183.10
6	R_LIGHTP	Residential Lighting – PLAN	1.53	2.13	13,984	29,680	0.0344	0.0344	175.98	175.98
7	R_WTRHTP	Residential Water Heating – PLAN	1.10	1.53	162	884	0.0480	0.0480	232.19	232.19
8	I_RATESP	Industrial Rates – PLAN	3.32	3.57	49,561	54,739	0.0849	0.0849	19.35	19.35
9	I_MOTORP	Industrial Motor – PLAN	2.31	3.63	39,562	79,680	0.0156	0.0156	97.02	97.02
10	I_LIGHTP	Industrial Lighting – PLAN	1.44	2.26	12,749	36,404	0.0252	0.0252	146.51	146.51
11	IMTRDWNP	Industrial Motor Downsizing – PLAN	1.17	1.84	172	857	0.0308	0.0308	190.60	190.60
12	IMTRASDP	Industrial Adj. Speed Drive – PLAN	1.27	1.99	2,187	8,155	0.0283	0.0283	183.46	183.46
13	I_MTASD4	Ind. Hi–Use ASD – 120 kW	2.73	4.29	1,608	3,060	0.0132	0.0132	88.57	88.57
14	I_LTMH01	Ind. Metal Halide Lighting	1.13	1.78	857	4,954	0.0320	0.0320	186.03	186.03
15	I_LTLB01	Ind. Hi–use Eff. Lamps & Ballasts T–8	1.52	2.38	6,842	18,240	0.0239	0.0239	139.13	139.13
16	C_LTOS01	Comm. Occupancy Sensors	1.06	1.51	29	265	0.0451	0.0451	277.81	277.81
17	R_RFSM01	Res. Refrigeration – Small	2.22	3.26	2,031	3,766	0.0198	0.0198	163.59	163.59
18	I_MTASD1	Ind. Low–Use ASD – 120 kW	1.12	1.76	446	2,838	0.0321	0.0321	211.29	211.29
19	I_MTASD3	Ind. Hi–Use ASD – 17.5 kW	1.51	2.39	1,250	3,373	0.0236	0.0236	146.65	146.65
20	ST_LIGHT	Street Lighting	2.18	3.33	22,084	43,355	0.0180	0.0180	70.73	70.73
21	I_PROC01	Ind. Process Monitoring	1.17	1.84	1,221	6,033	0.0309	0.0309	186.71	186.71
22	I_MTEF07	Ind. Hi–use 120 kW Rewind	2.83	4.45	1,359	2,566	0.0127	0.0127	78.69	78.69
23	I_MTEF06	Ind. HI–use 17.5 kW Rewind	3.78	5.94	4,577	8,143	0.0095	0.0095	58.76	58.76
24	I_MTDWN1	Ind. Motors – Downsizing	1.59	2.50	443	1,128	0.0226	0.0226	140.06	140.06
25	I_MTEF01	Ind. Low–use 3.5 kW retirement	1.63	2.57	531	1,320	0.0220	0.0220	137.63	137.63
26	I_RTINT1	Ind. Rates – Interruptible Service	8.83	8.91	48,621	49,155	0.2396	0.2396	6.64	6.64
27	I_RTTOU1	Ind. Rates – TOU	1.15	1.48	2,057	6,701	0.0621	0.0621	83.90	83.90

Exhibit 37: Summary of Assessment Results (cont'd.)

	NAME	DESCRIPTION	Benefit/Cost Ratio		Net Benefits ($)		Levelized Cost ($/kWh)		Levelized Cost ($/kW)	
			TRC Test	Societal Cost Test	TRC Test	Societal Cost Test	TRC Test	Societal Cost Test	TRC Test	Societal Cost Test
28	C_LTCF01	Comm. Low-use Compact Fluorescents	1.65	2.37	4,853	10,172	0.0288	0.0288	177.43	177.43
29	I_MTEF03	Ind. Low-use 120 kW Rewind	1.16	1.83	330	1,677	0.0309	0.0309	191.51	191.51
30	R_RFLG01	Res. Refrigeration - Large	2.19	3.21	5,374	10,021	0.0201	0.0201	165.94	165.94
31	I_PROC02	ind. Process Maintenance	1.34	2.11	3,584	11,608	0.0269	0.0269	162.66	162.66
32	I_MTEF05	Ind. HI-use 3.5 kW Rewind	2.75	4.33	33,053	62,903	0.0130	0.0130	81.54	81.54
33	R_LTCF01	Res. Low-Use Compact Fluorescents	1.57	2.08	7,407	14,129	0.0400	0.0400	142.14	142.14
34	C_LTCF02	Comm. Hi-use Compact Fluorescents	1.86	2.67	5,192	10,062	0.0256	0.0256	157.46	157.46
35	I_LTHPS1	Ind. High Pressure Sodium Lighting	1.67	2.61	5,760	13,920	0.0218	0.0218	126.55	126.55
36	R_WHWP01	Res. Water Heater Wrap	1.90	2.64	872	1,594	0.0278	0.0278	134.31	134.31
37	R_LTCF02	Res. Hi-use Compact Fluorescents	1.59	2.31	7,287	16,261	0.0286	0.0286	217.87	217.87
38	I_MTEF02	Ind. Motors 17.5 kW Rewind	1.16	1.83	829	4,189	0.0309	0.0309	190.61	190.61
39	C_LTFB01	Commercial HI-use Lamps and Ballasts to T-8	1.46	2.09	1,770	4,195	0.0326	0.0326	200.64	200.64

Program 1 is the aggregation of all programs
Programs 2 – 12 are the sector/end-use program aggregations
Programs 13 – 38 are individual programs

all programs and plans are economically justified even with zero environmental costs. The benefit/cost ratio of the entire plan is 1.87 without environmental costs, and 2.66 with environmental costs. Although some programs have benefit/cost ratios greater than 5, most are in the 1.1 to 3.0 range with environmental costs set to zero. These results are based on streams of benefits and costs that often go beyond the lifetime of the program since measures installed during the program yield savings during their entire lifetime, which is usually longer than the program.

4.4 SENSITIVITY ANALYSIS

Most of the parameter values used in this assessment have been adopted with a high level of confidence. If anything, the values of parameters such as measure savings are conservative since they are often based on extensive research conducted in the United States, where the energy consumption difference between standard and high-efficiency equipment may not be as great as it is in Poland. Avoided energy and generation capacity costs have been taken from the Tariff Study, which carried out a thorough analysis of these costs. The costs of conventional equipment and measures are taken in many cases from actual price sheets or technology surveys.

The values used for capital costs, load impacts, environmental costs, administrative costs, and participation rates are, however, more uncertain. Sensitivity analysis was carried out to determine whether this uncertainty in these values could affect the economic justification for these programs.

As discussed in Section 4.1, environmental costs could take on a wide range of values. Exhibit 37 suggests that even if conventional generation had no environmental costs, DSM programs would still be justified solely on the basis of production and capacity cost savings. DSM does not depend on environmental considerations to be cost effective; allocating environmental costs to conventional power supply only improves the case for DSM.

Because direct program costs and benefits accrue on a per-installation basis, changes in participation rates do not affect the benefit/cost ratio for individual programs. However, when fixed overhead costs are included, changes in participation rates can affect these ratios. If participation falls, administrative costs are spread over fewer participants and costs per participant increase. In effect, increases in fixed program overheads and reductions in participation have the same effect: both increase costs on a per-participant basis and thereby reduce the benefit/cost ratios.

As suggested in Section 4.2, both administrative costs and participation rates vary widely for programs that have been implemented in the United States. Results from several programs in the United States are shown in Exhibit 38. Since both administrative costs and participation rates are expected to vary with the type of program, the sector, delivery mechanism, and measures have been indicated. There is no clear pattern in these data that can help estimate the value of these parameters. Part of the discrepancy is due simply to different definitions of administrative costs and the pool of eligible customers. Both administrative costs and participation rates were developed in Section 4.2 specifically for Poland because experience in the United States can provide little guidance in estimating these parameters.

Even though the administrative costs and participation rates used in this analysis represent the best estimates available, there is still a great deal of uncertainty surrounding them. To determine how changes in these two parameters would affect the economic attractiveness of these programs, a probabilistic program evaluation was conducted with DSManager.

Values for each of these parameters were represented as probability distributions, and the resulting distributions for the benefit/cost ratios were calculated using Monte Carlo simulation techniques. For administrative costs, it was assumed that actual costs would lie between 90 percent and 140 percent of the baseline costs with 70 percent confidence, and would lie between 80 percent and 200 percent of baseline costs with 99 percent confidence.

For participation rates, it was assumed that actual participation would lie between 70 percent and 110 percent of the baseline participation with 70 percent confidence, and would lie between 30 percent and 120 percent of baseline participation with 99 percent confidence.

To account for uncertainty in the load impacts of the program as well as in program capital costs, capital costs and load impacts were assumed to lie between 80 percent and 120 percent of their baseline values with 70 percent confidence, and between 50 percent and 150 percent of their baseline values with 99 percent confidence.

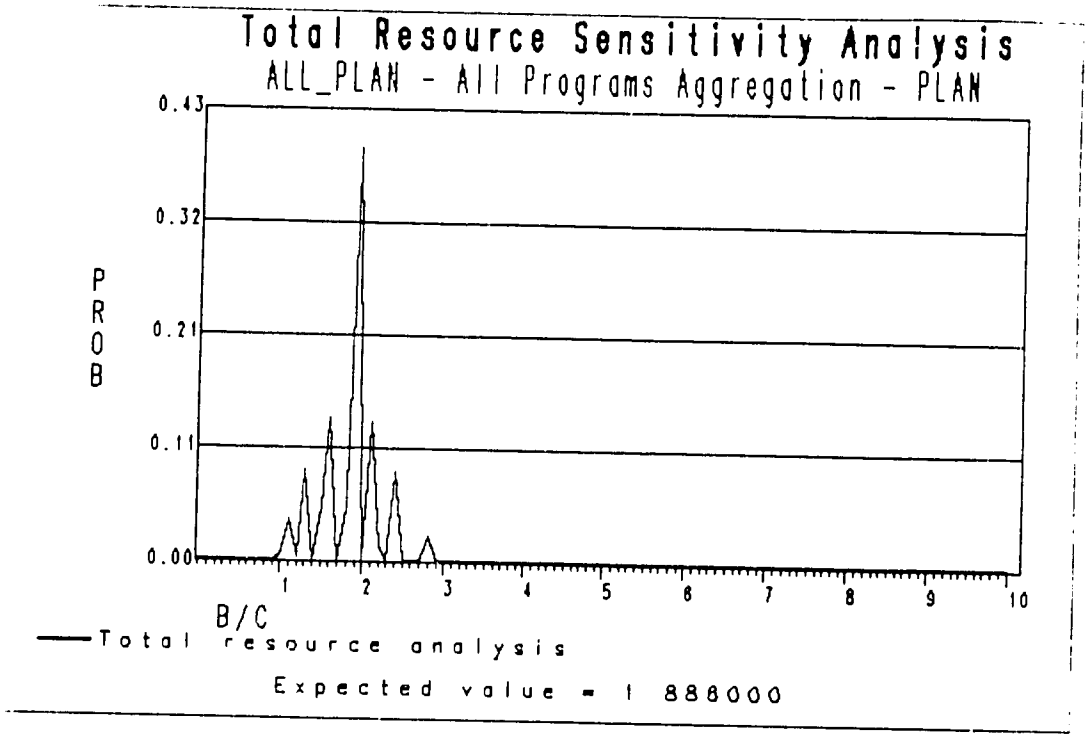
The sensitivity analysis revealed that the resulting distribution of benefit/cost ratios remained entirely greater than 1 for most plans and programs. The benefit/cost distributions are shown in Exhibit 39 for the total DSM plan and for the residential water heating plan, which was characterized by the lowest average benefit/cost ratio among the program aggregations. Even for the residential water heating program, the likelihood of the benefit/cost ratio remaining greater than one, taking into account the uncertainty in the parameters listed above, is around 2 to 1. This analysis suggests that the results of this assessment are valid over a wide range of parameter values.

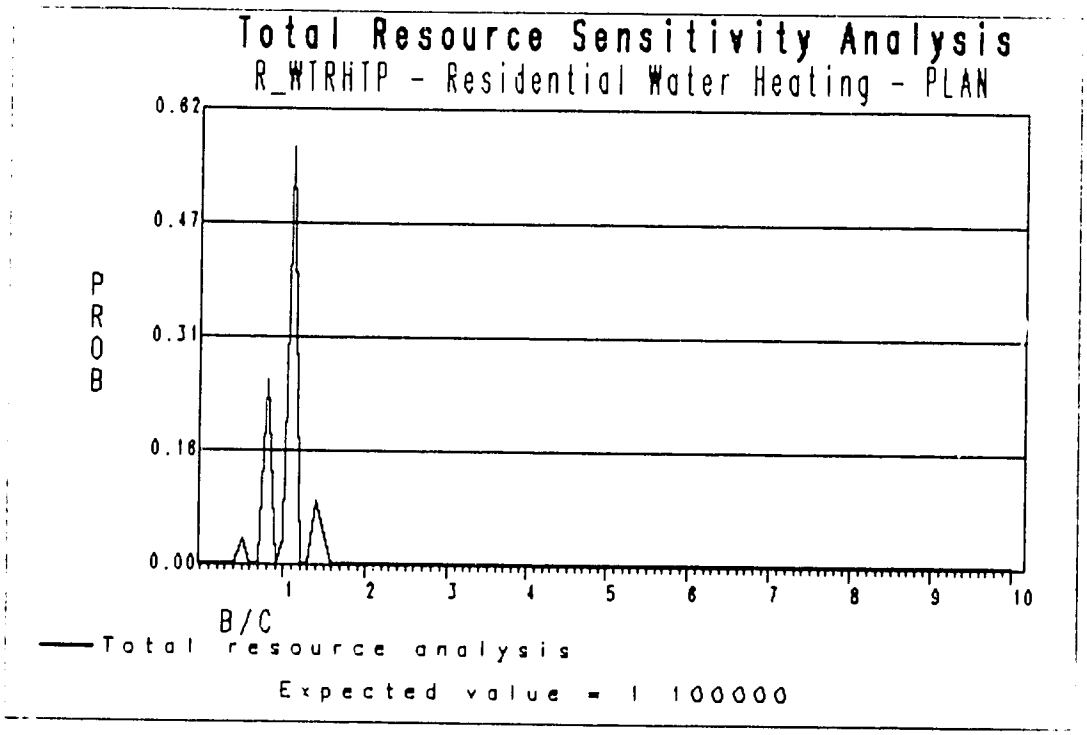
Exhibit 38: Administrative Costs and Participation Rates for Selected DSM Programs in North America

Utility	Program Name	Years Covered	Sector	Mechanism	Primary Measures	Admin. Cost %	Total Participation
NEES	Small C/I	1989 – 1991	C I	incentives	various	11.0%	5,312 participants (9%)
SCE	Low Income Relamp	1985 – 1991	R	direct install	CFLs	5.9%	361,527 homes (48%)
BED	Smartlight	1990 – 1992	R	leasing	CFLs	13.0%	5,624 households
PG&E	Custom Rebate	1990 – 1991	C I	incentives	various	13.3%	3,801 participants (<1%)
BPA	Super Good Cents	1985 – 1991	R	incentives	envelope	14.0%	39,667 homes (25%)
Con Edison	Enlightened Energy	1989 – 1991	C I	incentives	various	33.2%	3,076 rebates
BCHydro	Refrigerator Buy–Back	1990 – 1991	R	incentives	refrigerator	17.9%	16,928 refrigerators
Austin	Energy Star	1986 – 1992	R	home rating	envelope	68.2%	3,548 homes built
BPA	Hood River	1983 – 1985	C I R	community–based	envelope	9.1%	3,189 homes (91%)
SMUD	Comm. Lighting	1986 – 1988	C	direct install	lighting	60.3%	7,339 participants (45%)
PG&E	Showerhead	1991	R	incentives	showerheads	8.0%	553,431 showerheads
UI	Homeworks	1990 – 1992	R	direct install	weatherization	5.0%	22,504 participants (23%)
Ont. Hydro	Espanola	1991	C I R	community–based	envelope	11.9%	1,767 sites completed (87%)
NYPA	HELP	1990 – 1992	C	incentives	lighting	13.0%	144 projects
BPA	E$P	1988 – 1992	I	incentives	various	10.0%	55 participants (2.75%)
WMECO	Neighborhood	1991 – 1992	R	direct install	weatherization	32.0%	9,144 units
BECo	Res. Eff. Lighting	1987 – 1991	R	incentives	CFLs	7.0%	88,929 households (14%)
PG&E	Retrofit Program	1990 – 1991	C I	incentives	various	10.0%	30,071,312 items
EM&R	R–2000	1981 – 1991	R	home rating	envelope	13.3%	~6,000 certified homes
SCE	EMHRP	1987 – 1991	C I	incentives	various	16.3%	28,508 measures
BPA	MAP	1992 – 1995	R	incentives	envelope	12.0%	48,000 homes predicted (100%)
BECo	Small C/I	1990 – 1991	C I	direct install	various	7.5%	1,718 participants (2%)
PG&E	Com... New Const.	1990 – 1991	C	incentives	various	64.0%	75 projects paid (25%)
NEES	Res. Space Heat	1990 – 1992	R	direct install	weatherization	6.0%	6,547 homes (12%)
BPA	Energy Smart Design	1987 – 1992	C I	incentives	various	10.0%	660 design assistance
BCHydro	High Eff. Motors	1988 – 1991	C I	incentives	motors	45.8%	535,339 horsepower
BED	Heat Exchange	1989 – 1991	R	incentives	fuel–switching	17.0%	753 housing units (32%)

Sectors: C = commercial; I = industrial; R = residential
Primary Measures: "Various" typically includes lighting, HVAC, motors, and process equipment
Admin Cost %: Value is expressed as a percentage of total utility expenditure on the program.
Total Participation: Percentage represents portion of total eligible customers who participated.

Exhibit 39
Selected Sensitivity Analysis Results





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CHAPTER 5: IMPLEMENTING DSM AS A COMPONENT OF POWER SECTOR RESTRUCTURING

The preceding chapter developed a set of DSM programs that could be considered for Poland and conducted both individual and aggregated economic analyses of those programs. The results showed that these programs would be economically justified, even for a wide range of participation rates and environmental and administrative costs. This chapter assesses the achievable DSM potential associated with those programs, i.e., the actual energy savings that could be expected if these programs were implemented. It thereby provides a realistic assessment of cost-effective demand-side resources in Poland that could be counted on to meet consumer needs at least cost under a near-term DSM project.

This chapter also presents the economic analysis in terms that could be used to support the appraisal of a DSM component of an MDB power sector loan to Poland. It concludes with an overview of the next steps required to further develop demand-side resources in Poland: the design of a pilot program and the formulation of a regulatory framework.

5.1 THE CASE FOR DSM

The analysis conducted with DSManager demonstrated the cost-effectiveness of selected DSM programs in Poland. Moreover, these demand-side resources represent a significant power sector resource. This significance is expressed below in both physical and economic terms.

Achievable DSM Potential in Poland

Exhibit 40 presents a summary of the energy and demand savings in Poland in 2000 that could be achieved from the implementation of the DSM programs described in Chapter 4. The achievable energy savings potential is 1,738 GWh per year, equivalent to 8 percent of incremental energy requirements. The achievable demand savings potential is 552 MW, equivalent to 17 percent of incremental demand requirements, which would displace all of the planned capacity additions through 2000 called for in the Supply Plan. Assuming average auxiliary and network losses of 16.3 percent, the DSM program would be equivalent to the 18th-largest power plant in Poland in energy terms and the 14th-largest in capacity

Exhibit 40
Summary of Achievable Energy and Demand Savings in Poland in the Year 2000

PROGRAM	Energy (GWh)	Demand (MW)	Share of Incremental Energy (1995-2000)*	Share of Incremental Demand (1995-2000)**
Residential Lighting	267	48	1.2%	1.5%
Residential Refrigeration	65	8	0.3%	0.2%
Residential Water Heating	11	2	0.1%	0.1%
RESIDENTIAL SUBTOTAL	**343**	**58**	**1.6%**	**1.8%**
Commercial Lighting	225	36	1.1%	1.3%
COMMERCIAL SUBTOTAL	**225**	**36**	**1.1%**	**1.3%**
Industrial Motors	401	64	1.8%	2.0%
Drives	68	10	0.3%	0.3%
Motor Downsizing	7	1	0.0%	0.0%
Industrial Process	171	28	0.8%	0.9%
Industrial Lighting	256	44	1.2%	1.4%
Industrial Rates	59	258	0.0%	7.9%
INDUSTRIAL SUBTOTAL	**962**	**405**	**4.4%**	**12.5%**
Street Lighting	208	53	1.0%	1.6%
PUBLIC SECTOR SUBTOTAL	**208**	**53**	**1.0%**	**1.6%**
TOTAL SAVINGS	**1,738**	**552**	**8.1%**	**17.2%**

Note: totals may not add because they have been rounded.
* Incremental energy growth is calculated from the Electric Power Tariff Study: Polish Power Grid Company, Draft Report, February 1993.
**In the modeling exercise, incremental demand growth between 1995 and 2000 is calculated as 3,253 MW.

terms.[39] As noted in Section 1.2, there are 55 dedicated thermal power plants in Poland and approximately 400 generating units overall.

The Economics of a Full-Scale DSM Program

The economic significance of this DSM program is commensurate with its physical significance. Exhibit 41 provides an economic analysis of program costs and benefits on an annual basis from 1994 through 2020. Although the program itself ends in 2000, the benefits of DSM measures installed under the program continue to accrue over the lifetime of the measures, often beyond the duration of the program.

Exhibit 41 includes the economic value of capacity and energy savings benefits as well as the administrative and incremental capital costs of the entire DSM program, and takes into account the expected participation in the each individual program. Adminstrative costs, which represent nearly 45 percent of total economic cost in the first year of the program, fall to 18 percent of total costs by the last year of the program as program implementation is established. Taking all of these costs and benefits into account, the net present value of the entire program is US$159 million.

A multilateral development bank loan could be used to finance a portion of the utility costs of a DSM program. Costs in Exhibit 41, however, are typically paid for by participating customers and the utility (and indirectly non-participating consumers through changes in the tariff structure). The allocation of these costs between the different parties cannot be determined until a regulatory framework is in place. Moreover, some of these costs only displace costs the consumers would have otherwise paid for electricity had they not participated in the program. Therefore, Exhibit 41 should not be interpreted as suggesting a DSM loan amount or the precise use of loan funds. It does, however, conclusively demonstrate the economic justification for DSM lending.

Clearly, DSM has a place among Poland's power system options for the coming decade and beyond. Power sector restructuring efforts currently underway in Poland should take into account the potential contribution of demand-side resources. The IRP analysis will define the role of DSM with more precision. In the meantime, two activities should be carried out to further enhance the prospects for DSM in Poland.

[39] Both the portion of future energy sales and system demand, as well as the ranking of power plants by size, are taken from the Tariff Study.

TABLE 41

TOTAL DSM PROGRAM COSTS AND BENEFITS

PROGRAM	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Residential Lighting														
Costs:														
Capital + O&M	$0	$464,450	$1,393,360	$3,251,170	$5,254,220	$6,938,070	$6,836,730	$5,240,690	$3,644,650	$2,687,030	$2,687,030	$2,687,030	$2,541,780	$2,251,290
Prog Admin	$0	$815,000	$1,080,000	$2,010,000	$2,475,000	$2,475,000	$1,185,000	$0	$0	$0	$0	$0	$0	$0
Benefits:														
MWh Saved	0	18,632	55,896	130,425	209,491	274,464	267,178	196,709	126,241	83,960	83,960	83,960	79,421	70,344
MW Saved	0	3	9	22	36	48	48	38	29	24	24	24	22	20
Value of MWh Saved	$0	$503,670	$1,511,000	$3,525,670	$5,662,390	$7,417,500	$7,218,960	$5,310,890	$3,402,810	$2,257,960	$2,257,960	$2,257,960	$2,135,910	$1,891,810
Value of MW Saved	$0	$287,480	$1,266,300	$2,954,720	$4,805,920	$6,397,840	$6,382,760	$5,086,290	$3,789,810	$3,011,920	$3,011,920	$3,011,920	$2,849,120	$2,523,500
Residential Refrigeration														
Costs:														
Capital + O&M	$0	$710,410	$710,410	$1,420,810	$1,420,810	$2,131,220	$2,131,220	$0	$0	$0	$0	$0	$0	$0
Prog Admin	$0	$551,060	$351,060	$552,110	$552,110	$753,170	$753,170	$0	$0	$0	$0	$0	$0	$0
Benefits:														
MWh Saved	0	5,453	10,905	21,810	32,716	49,073	65,431	65,431	65,431	65,431	65,431	65,431	65,431	65,431
MW Saved	0	1	1	3	4	6	8	8	8	8	8	8	8	8
Value of MWh Saved	$0	$144,160	$288,320	$576,630	$864,950	$1,297,420	$1,729,890	$1,729,890	$1,729,890	$1,729,890	$1,729,890	$1,729,890	$1,729,890	$1,729,890
Value of MW Saved	$0	$60,640	$191,230	$382,460	$573,690	$860,530	$1,147,390	$1,147,390	$1,147,390	$1,147,390	$1,147,390	$1,147,390	$1,147,390	$1,147,390
Residential Water Heating														
Costs:														
Capital + O&M	$0	$60,800	$121,600	$243,200	$304,000	$304,000	$182,400	$0	$0	$0	$0	$0	$0	$0
Prog Admin	$0	$374,000	$198,000	$246,000	$270,000	$270,000	$222,000	$0	$0	$0	$0	$0	$0	$0
Benefits:														
MWh Saved	0	548	1,645	3,839	6,581	9,323	10,968	10,968	10,968	10,419	9,323	7,129	4,387	1,645
MW Saved	0	0	0	1	1	2	2	2	2	2	2	1	1	0
Value of MWh Saved	$0	$14,650	$43,950	$102,560	$175,820	$249,080	$293,030	$293,030	$293,030	$278,380	$249,080	$190,470	$117,210	$43,950
Value of MW Saved	$0	$10,440	$42,840	$99,970	$171,380	$242,790	$285,630	$285,630	$285,630	$271,350	$242,790	$185,660	$114,250	$42,840
Commercial Lighting														
Costs:														
Capital + O&M	$0	$328,130	$988,040	$2,007,720	$3,189,520	$4,261,000	$4,529,330	$3,655,330	$2,792,930	$1,998,770	$1,504,630	$1,010,480	$714,000	$714,000
Prog Admin	$0	$784,770	$952,870	$1,755,700	$2,123,800	$2,190,470	$1,454,270	$0	$0	$0	$0	$0	$0	$0
Benefits:														
MWh Saved	0	14,731	42,121	96,901	156,692	210,908	224,511	181,394	133,395	90,929	66,526	42,122	27,480	27,480
MW Saved	0	2	7	16	25	34	36	29	22	15	11	7	4	4
Value of MWh Saved	$0	$393,280	$1,124,520	$2,586,970	$4,183,220	$5,630,620	$5,993,790	$4,842,670	$3,561,250	$2,427,550	$1,776,040	$1,124,530	$733,630	$733,630
Value of MW Saved	$0	$219,920	$883,580	$2,032,700	$3,286,930	$4,424,210	$4,709,570	$3,805,090	$2,798,220	$1,907,420	$1,395,510	$883,580	$576,450	$576,450
Industrial Motors														
Costs:														
Capital + O&M	$0	$4,354,160	$4,354,160	$8,708,320	$8,708,320	$9,809,010	$9,809,010	$0	$0	$0	$0	$0	$0	$0
Prog Admin	$0	$959,500	$709,500	$1,169,010	$1,169,010	$1,231,540	$1,231,540	$0	$0	$0	$0	$0	$0	$0
Benefits:														
MWh Saved	0	39,139	78,278	156,557	234,835	317,808	400,780	400,780	400,780	400,780	400,780	400,780	400,780	400,780
MW Saved	0	6	13	25	38	51	64	64	64	64	64	64	64	64
Value of MWh Saved	$0	$1,040,390	$2,080,780	$4,161,570	$6,242,350	$8,447,830	$10,653,300	$10,653,300	$10,653,300	$10,653,300	$10,653,300	$10,653,300	$10,653,300	$10,653,300
Value of MW Saved	$0	$100,440	$736,130	$1,472,260	$2,208,400	$2,989,070	$3,769,740	$3,769,740	$3,769,740	$3,769,740	$3,769,740	$3,769,740	$3,769,740	$3,769,740
Drive Measures														
Costs:														
Capital + O&M	$0	$630,800	$1,234,000	$1,864,800	$2,490,000	$3,115,200	$3,115,200	$0	$0	$0	$0	$0	$0	$0
Prog Admin	$0	$511,400	$272,400	$283,800	$295,000	$306,200	$306,200	$0	$0	$0	$0	$0	$0	$0
Benefits:														
MWh Saved	0	3,465	10,144	20,287	33,864	50,874	67,884	67,884	67,884	67,884	67,884	67,884	67,884	67,884
MW Saved	0	1	2	3	5	8	10	10	10	10	10	10	10	10
Value of MWh Saved	$0	$91,000	$266,360	$532,710	$889,230	$1,335,890	$1,782,550	$1,782,550	$1,782,550	$1,782,550	$1,782,550	$1,782,550	$1,782,550	$1,782,550
Value of MW Saved	$0	$8,560	$98,330	$196,680	$328,310	$493,240	$658,170	$658,170	$658,170	$658,170	$658,170	$658,170	$658,170	$658,170

TABLE 41

TOTAL DSM PROGRAM COSTS AND BENEFITS

PROGRAM	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Industrial Motor Downsizing														
Costs:														
Capital + O&M	$0	$16,800	$33,600	$50,400	$67,200	$84,000	$84,000	$0	$0	$0	$0	$0	$0	$0
Prog Admin	$0	$361,200	$172,400	$183,600	$194,800	$206,000	$206,000	$0	$0	$0	$0	$0	$0	$0
Benefits:														
MWh Saved	0	355	1,065	2,129	3,549	5,323	7,098	7,098	7,098	7,098	7,098	7,098	7,098	7,098
MW Saved	0	0	0	0	1	1	1	1	1	1	1	1	1	1
Value of MWh Saved	$0	$9,420	$28,250	$56,490	$94,150	$141,230	$188,310	$188,310	$188,310	$188,310	$188,310	$188,310	$188,310	$188,310
Value of MW Saved	$0	$920	$10,120	$20,250	$33,750	$50,620	$67,500	$67,500	$67,500	$67,500	$67,500	$67,500	$67,500	$67,500
Industrial Operations Improvement														
Costs:														
Capital + O&M	$0	$945,000	$1,924,500	$3,904,000	$5,018,000	$5,247,500	$3,587,000	$897,000	$897,000	$897,000	$897,000	$852,000	$762,500	$583,000
Prog Admin	$0	$860,000	$966,000	$1,686,000	$2,042,000	$2,044,000	$1,326,000	$0	$0	$0	$0	$0	$0	$0
Benefits:														
MWh Saved	0	8,600	25,703	60,006	102,813	145,680	171,383	171,383	171,383	171,383	171,383	162,783	145,680	111,377
MW Saved	0	1	4	10	17	24	28	28	28	28	28	27	24	18
Value of MWh Saved	$0	$228,340	$682,480	$1,593,290	$2,729,900	$3,868,100	$4,550,580	$4,550,580	$4,550,580	$4,550,580	$4,550,580	$4,322,240	$3,868,100	$2,957,290
Value of MW Saved	$0	$22,750	$247,280	$577,280	$989,110	$1,401,500	$1,648,780	$1,648,780	$1,648,780	$1,648,780	$1,648,780	$1,566,040	$1,401,500	$1,071,490
Industrial Lighting														
Costs:														
Capital + O&M	$0	$287,910	$1,151,630	$2,303,260	$3,454,890	$4,606,520	$5,758,150	$5,758,150	$5,758,150	$5,758,150	$5,758,150	$5,758,150	$5,758,150	$5,614,930
Prog Admin	$0	$541,500	$724,500	$916,000	$916,000	$916,000	$916,000	$0	$0	$0	$0	$0	$0	$0
Benefits:														
MWh Saved	0	12,821	51,285	102,570	153,855	205,140	256,425	256,425	256,425	256,425	256,425	256,425	256,425	249,538
MW Saved	0	2	9	18	26	35	44	44	44	44	44	44	44	43
Value of MWh Saved	$0	$341,200	$1,364,790	$2,729,580	$4,094,370	$5,459,150	$6,823,940	$6,823,940	$6,823,940	$6,823,940	$6,823,940	$6,823,940	$6,823,940	$6,640,660
Value of MW Saved	$0	$35,290	$500,370	$1,000,750	$1,501,110	$2,001,480	$2,501,850	$2,501,850	$2,501,850	$2,501,850	$2,501,850	$2,501,850	$2,501,850	$2,434,650
Industrial Rates														
Costs:														
Capital + O&M	$0	$1,462,500	$2,925,000	$4,387,500	$5,850,000	$7,312,500	$7,338,500	$0	$0	$0	$0	$0	$0	$0
Prog Admin	$0	$842,500	$935,000	$1,277,500	$1,620,000	$1,962,500	$1,969,000	$0	$0	$0	$0	$0	$0	$0
Benefits:														
MWh Saved	0	2,941	8,824	17,648	29,414	44,121	58,897	58,897	58,897	58,897	58,897	58,897	58,897	58,897
MW Saved	0	13	39	77	129	194	258	258	258	258	258	258	258	258
Value of MWh Saved	$0	$83,920	$1,251,750	$503,500	$839,170	$1,258,760	$1,680,290	$1,680,290	$1,680,290	$1,680,290	$1,680,290	$1,680,290	$1,680,290	$1,680,290
Value of MW Saved	$0	$206,610	$2,254,110	$4,508,220	$7,513,700	$11,270,550	$15,030,350	$15,030,350	$15,030,350	$15,030,350	$15,030,350	$15,030,350	$15,030,350	$15,030,350
Street Lighting														
Costs:														
Capital + O&M	$0	$183,590	$550,780	$1,285,140	$2,203,100	$3,121,070	$3,671,840	$3,671,840	$3,671,840	$3,671,840	$3,671,840	$3,671,840	$3,671,840	$3,671,840
Prog Admin	$0	$383,410	$216,830	$283,660	$317,070	$317,070	$250,240	$0	$0	$0	$0	$0	$0	$0
Benefits:														
MWh Saved	0	10,385	31,157	72,699	124,627	176,555	207,712	207,712	207,712	207,712	207,712	207,712	207,712	207,712
MW Saved	0	3	8	19	32	45	53	53	53	53	53	53	53	53
Value of MWh Saved	$0	$273,070	$819,230	$1,911,530	$3,276,920	$4,642,310	$5,461,530	$5,461,530	$5,461,530	$5,461,530	$5,461,530	$5,461,530	$5,461,530	$5,461,530
Value of MW Saved	$0	$42,410	$411,750	$960,740	$1,646,980	$2,333,230	$2,744,980	$2,744,960	$2,744,980	$2,744,980	$2,744,980	$2,744,980	$2,744,980	$2,744,980
ALL PROGRAMS														
COSTS:														
Capital + O&M	$0	$9,444,550	$15,287,080	$29,426,320	$37,960,060	$46,930,090	$47,043,380	$19,223,010	$16,764,570	$15,012,790	$14,518,650	$13,979,500	$13,448,270	$12,835,060
Prog Admin	$0	$6,984,340	$6,578,560	$10,363,380	$11,974,790	$12,671,950	$9,819,420	$0	$0	$0	$0	$0	$0	$0
National Overhead	$555,000	$555,000	$555,000	$555,000	$555,000	$555,000	$555,000	$0	$0	$0	$0	$0	$0	$0
TOTAL COSTS	**$555,000**	**$16,983,890**	**$22,420,640**	**$40,344,700**	**$50,489,850**	**$60,157,040**	**$57,417,800**	**$19,223,010**	**$16,764,570**	**$15,012,790**	**$14,518,650**	**$13,979,500**	**$13,448,270**	**$12,835,060**
BENEFITS:														
MWh Saved	0	117,072	317,024	684,871	1,088,437	1,489,270	1,738,268	1,624,681	1,506,214	1,420,919	1,395,418	1,360,221	1,321,195	1,268,186
MW Saved	0	32	92	193	314	447	554	538	521	508	504	498	491	481
Value of MWh Saved	$0	$3,123,100	$8,461,430	$18,280,500	$29,052,470	$39,747,890	$46,376,170	$43,316,980	$40,127,480	$37,834,280	$37,153,470	$36,215,010	$35,174,660	$33,763,210
Value of MW Saved	$0	$995,460	$6,642,040	$14,206,030	$23,059,280	$32,465,060	$38,946,720	$36,745,770	$34,442,420	$32,759,450	$32,218,980	$31,567,180	$30,861,300	$30,067,060
TOTAL BENEFITS	**$0**	**$4,118,560**	**$15,103,470**	**$32,486,530**	**$52,111,750**	**$72,212,950**	**$85,322,890**	**$80,062,750**	**$74,569,900**	**$70,593,730**	**$69,372,450**	**$67,782,190**	**$66,035,960**	**$63,830,270**
TOTAL NET BENEFITS (COST)	**($555,000)**	**($12,865,330)**	**($7,317,170)**	**($7,858,170)**	**$1,621,900**	**$12,055,910**	**$27,905,090**	**$60,839,740**	**$57,805,330**	**$55,580,940**	**$54,853,800**	**$53,802,690**	**$52,587,690**	**$50,995,210**

TOTAL NET PRESENT VALUE: $158,734,450

TABLE 41 CONT'D

TOTAL DSM PROGRAM COSTS AND BENEFITS

PROGRAM	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Residential Lighting													
Costs:													
Capital + O&M	$1,670,320	$944,090	$217,870	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Prog Admin	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Benefits:													
MWh Saved	52,191	29,499	6,808	0	0	0	0	0	0	0	0	0	0
MW Saved	15	8	2	0	0	0	0	0	0	0	0	0	0
Value of MWh Saved	$1,403,600	$793,340	$183,080	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Value of MW Saved	$1,872,280	$1,058,240	$244,210	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Residential Refrigeration													
Costs:													
Capital + O&M	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Prog Admin	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Benefits:													
MWh Saved	65,431	65,431	65,431	65,431	65,431	65,431	65,431	59,979	54,526	43,621	32,716	16,358	0
MW Saved	8	8	8	8	8	8	8	7	7	5	4	2	0
Value of MWh Saved	$1,729,890	$1,729,890	$1,729,890	$1,729,890	$1,729,890	$1,729,890	$1,729,890	$1,585,740	$1,441,580	$1,153,260	$864,950	$432,470	$0
Value of MW Saved	$1,147,390	$1,147,390	$1,147,390	$1,147,390	$1,147,390	$1,147,390	$1,147,390	$1,051,760	$956,150	$764,920	$573,690	$286,840	$0
Residential Water Heating													
Costs:													
Capital + O&M	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Prog Admin	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Benefits:													
MWh Saved	0	0	0	0	0	0	0	0	0	0	0	0	0
MW Saved	0	0	0	0	0	0	0	0	0	0	0	0	0
Value of MWh Saved	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Value of MW Saved	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Commercial Lighting													
Costs:													
Capital + O&M	$714,000	$714,000	$714,000	$714,000	$714,000	$714,000	$714,000	$654,500	$595,000	$476,000	$357,000	$178,500	$0
Prog Admin	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Benefits:													
MWh Saved	27,480	27,480	27,349	27,088	26,565	25,912	25,259	22,795	20,723	16,578	12,434	6,217	0
MW Saved	4	4	4	4	4	4	4	4	3	3	2	1	0
Value of MWh Saved	$733,630	$733,630	$730,140	$723,160	$709,210	$691,770	$674,340	$608,550	$553,230	$442,580	$331,940	$165,970	$0
Value of MW Saved	$576,450	$576,450	$573,700	$568,220	$557,260	$543,560	$529,860	$478,160	$434,690	$347,750	$260,820	$130,410	$0
Industrial Motors													
Costs:													
Capital + O&M	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Prog Admin	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Benefits:													
MWh Saved	400,780	400,780	400,780	400,780	400,780	400,780	400,780	361,641	322,502	244,224	165,945	82,973	0
MW Saved	64	64	64	64	64	64	64	58	52	39	27	13	0
Value of MWh Saved	$10,653,300	$10,653,300	$10,653,300	$10,653,300	$10,653,300	$10,653,300	$10,653,300	$9,61[illegible]10	$8,572,510	$6,491,730	$4,410,940	$2,205,470	$0
Value of MW Saved	$3,769,740	$3,769,740	$3,769,740	$3,769,740	$3,769,740	$3,769,740	$3,769,740	$3,401,670	$3,033,600	$2,297,470	$1,561,350	$780,670	$0
Drive Measures													
Costs:													
Capital + O&M	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Prog Admin	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Benefits:													
MWh Saved	67,884	67,884	64,419	57,741	47,597	34,020	17,010	0	0	0	0	0	0
MW Saved	10	10	10	9	7	5	3	0	0	0	0	0	0
Value of MWh Saved	$1,782,550	$1,782,550	$1,691,560	$1,516,200	$1,249,840	$893,330	$446,660	$0	$0	$0	$0	$0	$0
Value of MW Saved	$658,170	$658,170	$624,570	$559,840	$461,490	$329,860	$164,930	$0	$0	$0	$0	$0	$0

TABLE 41 CONT'D

TOTAL DSM PROGRAM COSTS AND BENEFITS

PROGRAM	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Industrial Motor Downsizing													
Costs:													
Capital + O&M	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Prog Admin	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Benefits:													
MWh Saved	7,098	7,098	7,098	7,098	7,098	7,098	7,098	6,743	6,033	4,969	3,549	1,774	0
MW Saved	1	1	1	1	1	1	1	1	1	1	1	0	0
Value of MWh Saved	$188,310	$188,310	$188,310	$188,310	$188,310	$188,310	$188,310	$178,890	$160,060	$131,810	$94,150	$47,080	$0
Value of MW Saved	$67,500	$67,500	$67,500	$67,500	$67,500	$67,500	$67,500	$64,120	$57,380	$48,250	$33,750	$16,880	$0
Industrial Operations Improvement													
Costs:													
Capital + O&M	$359,000	$134,500	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Prog Admin	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Benefits:													
MWh Saved	68,570	25,703	0	0	0	0	0	0	0	0	0	0	0
MW Saved	11	4	0	0	0	0	0	0	0	0	0	0	0
Value of MWh Saved	$1,820,680	$682,480	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Value of MW Saved	$659,670	$247,280	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Industrial Lighting													
Costs:													
Capital + O&M	$5,185,280	$4,612,410	$4,039,550	$3,466,680	$2,893,810	$2,893,810	$2,893,810	$2,893,810	$2,893,810	$2,893,810	$2,893,810	$2,893,810	$2,893,810
Prog Admin	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Benefits:													
MWh Saved	228,876	201,327	173,778	146,230	118,681	118,681	118,681	118,681	118,681	118,681	118,681	118,681	118,681
MW Saved	39	35	30	25	20	20	20	20	20	20	20	20	20
Value of MWh Saved	$6,090,820	$5,357,690	$4,624,570	$3,891,440	$3,158,320	$3,158,320	$3,158,320	$3,158,320	$3,158,320	$3,158,320	$3,158,320	$3,158,320	$3,158,320
Value of MW Saved	$2,233,070	$1,964,290	$1,695,500	$1,426,720	$1,157,930	$1,157,930	$1,157,930	$1,157,930	$1,157,930	$1,157,930	$1,157,930	$1,157,930	$1,157,930
Industrial Rates													
Costs:													
Capital + O&M	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Prog Admin	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Benefits:													
MWh Saved	58,897	58,897	55,955	50,072	41,248	29,483	14,776	0	0	0	0	0	0
MW Saved	258	258	245	220	181	129	65	0	0	0	0	0	0
Value of MWh Saved	$1,680,290	$1,680,290	$1,596,380	$1,428,540	$1,176,790	$841,120	$421,540	$0	$0	$0	$0	$0	$0
Value of MW Saved	$15,030,350	$15,030,350	$14,278,990	$12,776,250	$10,522,140	$7,516,650	$3,759,800	$0	$0	$0	$0	$0	$0
Street Lighting													
Costs:													
Capital + O&M	$3,671,840	$3,671,840	$3,671,840	$3,671,840	$3,671,840	$3,671,840	$3,671,840	$3,671,840	$3,671,840	$3,671,840	$3,671,840	$3,671,840	$3,671,840
Prog Admin	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Benefits:													
MWh Saved	207,712	207,712	207,712	207,712	207,712	207,712	207,712	207,712	207,712	207,712	207,712	207,712	207,712
MW Saved	53	53	53	53	53	53	53	53	53	53	53	53	53
Value of MWh Saved	$5,461,530	$5,461,530	$5,461,530	$5,461,530	$5,461,530	$5,461,530	$5,461,530	$5,461,530	$5,461,530	$5,461,530	$5,461,530	$5,461,530	$5,461,530
Value of MW Saved	$2,744,980	$2,744,980	$2,744,980	$2,744,980	$2,744,980	$2,744,980	$2,744,980	$2,744,960	$2,744,980	$2,744,980	$2,744,980	$2,744,980	$2,744,980
ALL PROGRAMS													
COSTS:													
Capital + O&M	$11,600,440	$10,076,840	$8,643,260	$7,852,520	$7,279,650	$7,279,650	$7,279,650	$7,220,150	$7,160,650	$7,041,650	$6,922,650	$6,744,150	$6,565,650
Prog Admin	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
National Overhead	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
TOTAL COSTS	**$11,600,440**	**$10,076,840**	**$8,643,260**	**$7,852,520**	**$7,279,650**	**$7,279,650**	**$7,279,650**	**$7,220,150**	**$7,160,650**	**$7,041,650**	**$6,922,650**	**$6,744,150**	**$6,565,650**
BENEFITS:													
MWh Saved	1,184,919	1,091,812	1,009,330	962,152	915,113	889,117	856,747	777,550	730,176	635,784	541,036	433,715	326,393
MW Saved	465	447	418	384	339	285	218	143	136	121	107	90	73
Value of MWh Saved	$31,544,600	$29,063,010	$26,858,760	$25,592,370	$24,327,190	$23,617,570	$22,733,890	$20,605,940	$19,347,230	$16,839,230	$14,321,830	$11,470,840	$8,619,850
Value of MW Saved	$28,759,600	$27,264,390	$25,146,580	$23,060,640	$20,428,430	$17,277,610	$13,342,130	$8,898,620	$8,384,730	$7,360,300	$6,332,520	$5,117,710	$3,902,910
TOTAL BENEFITS	**$60,304,200**	**$56,327,400**	**$52,005,340**	**$48,653,010**	**$44,755,620**	**$40,895,180**	**$36,076,020**	**$29,504,560**	**$27,731,960**	**$24,199,530**	**$20,654,350**	**$16,588,550**	**$12,522,760**
TOTAL NET BENEFITS (COST)	**$48,703,760**	**$46,250,560**	**$43,362,080**	**$40,800,490**	**$37,475,970**	**$33,615,530**	**$28,796,370**	**$22,284,410**	**$20,571,310**	**$17,157,880**	**$13,731,700**	**$9,844,400**	**$5,957,110**

5.2 ESTABLISHING A FOUNDATION: FORMULATING A REGULATORY FRAMEWORK

The legal and regulatory framework under which the power sector operates in Poland should ensure that integrated resource planning (IRP) is the most profitable plan for the utility as well as the least-cost plan for its customers and society at large. Following are broad themes which would support the implementation of IRP and DSM covering the following topics:

- the purpose of integrated resource planning
- development of an integrated resource plan
- authority for PPGC to implement the integrated resource plan
- recovery by the distribution companies of DSM costs through electric rates
- ability of the distribution companies to earn financial incentives to implement DSM
- provision for public involvement

The Purpose of Integrated Resource Planning

Integrated resource planning is a comprehensive process through which utilities identify and acquire the most cost-effective electric resources necessary to meet their customers' incremental requirements for energy and power. IRP provides significant changes to the way that utilities traditionally have conducted business and also provides a strategic context in which to better understand the importance and role of demand-side management.

IRP is often called "least-cost" planning, which refers to the acquisition of electric resources by utilities at the lowest possible cost to themselves, their customers and society at large. "Electric resources" are available throughout the entire power system from the point of generation to the point of consumption. They include the traditional supply-side measures that provide megawatts from the construction of new generators, repowering and rehabilitating existing generation facilities, and purchasing power from wholesale markets or independent power producers. Electric resources also include measures that provide

"negawatts" from efficiency improvements in generators (better heat rates), the transmission and distribution system (fewer line losses) and at the end-use (demand-side management).

In determining which are the most cost-effective electric resources, it is important to calculate costs and benefits properly (the various cost tests were discussed in Section 1.3). Utilities have traditionally calculated costs and benefits strictly from their own perspective (using the Utility Cost Test). Thus, the benefits of a DSM program (utility avoided operating and capital costs) would have to exceed the costs of the program (administrative costs, financial incentives, and lost revenues from reduced consumption) for the program to be cost-effective. From this utility perspective, the most cost-effective DSM is that achieved by load management, preferably the shifting of load from peak to off-peak times.

An important innovation of IRP is the inclusion of costs and benefits of the utility's customers (the Total Resource Cost Test). Thus, customer bill savings from DSM add an important benefit that makes a number of energy efficiency measures cost-effective. Adding the customer's perspective to the benefit/cost analysis is increasingly important in economies such as Poland's that are struggling to be competitive in world markets.

Another innovation of IRP is the inclusion of benefits to society from the acquisition of electric resources that are environmentally benign, such as DSM and most renewable resources (the Societal Cost Test). The reduced social costs from reliance on technologies that do not create pollution from the combustion of fossil fuels are increasingly important in a country like Poland that has suffered tremendous environmental damages from uncontrolled power generation.

Polish energy law or regulations could provide an explicit requirement that electric resources in Poland are systematically identified and acquired to be the lowest-cost options from the perspectives of the utility, its customers, and all society. This approach will yield the most economically efficient outcome and will ensure the sustainable development of Poland's power system to meet current needs as well as those of future generations.

Development of an Integrated Resource Plan

Proposed energy legislation in Poland requires that an energy plan be developed by the Ministry of Industry and Trade every two years. It appears that this plan is intended to support government policy with subsequent plans to be developed by a proposed Energy Regulatory Agency (ERA) that will address specific actions by energy producers and consumers. ERA may be given the responsibility for overseeing the development by PPGC

of a detailed integrated resource plan for the electric sector which would include the following components:

(1) identifying the objectives of the plan (e.g., reliable service, minimal environmental effects, low cost of environmental controls, meeting peak demand in a cost-effective manner, and minimal bills for electricity customers)

(2) developing one or more load forecasts for different scenarios

(3) determining the levels of capacity expected for each year of the plan

(4) identifying needed resources (e.g., fuels, generating capacity, transmission and distribution capacity, a manageable load shape, and demand reductions) needed to bridge the gap between expected loads and capacities

(5) evaluating all of the electric resources in a consistent fashion and selecting the most promising resources for fashioning an effective, flexible, and responsive plan, integrating methods of supplying power with methods for controlling and moderating demand

(6) constructing scenarios that project the selected mixes of resources against possible economic, environmental, and social circumstances

(7) evaluating the economic and technical characteristics of each mix of resources and analyzing the uncertainties associated with the various scenarios

(8) screening the alternatives to eliminate those that are not suitable and rank-ordering alternative courses of action

(9) testing each alternative for cost-effectiveness from a variety of perspectives (e.g., the utilities, ratepayers of different classes, society at large)

(10) re-evaluating the alternatives considering economic, environmental, and societal factors and selecting a plan for implementation, one that most nearly satisfies all the objectives of the plan

(11) developing and implementing a plan of action

(12) monitoring and evaluating the operation of the utilities under the plan and revising the plan if necessary.

Authority for PPGC to Implement the Integrated Resource Plan

In order for IRP to function in Poland, it might be appropriate that the PPGC be given the authority to implement the plan, under ERA's regulatory oversight (although it may be determined that the distribution companies or others could also play this role). As the monopoly wholesale supplier, PPGC could assume the "obligation to serve" by taking the lead responsibility for acquiring both supply-side and demand-side resources according to the plan. "Acquiring" means arranging, directly or indirectly, for resources to be made available to the Polish electric system. PPGC could acquire resources through contracting with generating companies for power, contracting with distribution companies for DSM resources, or requesting competitive bids for supply-side and demand-side resources.

This does not mean that distribution companies would necessarily be excluded from building or purchasing supply-side resources. As presently proposed, some distribution companies would, under certain circumstances, still be able to build and operate their own generating facilities or contract directly with generators. Presumably, however, those facilities and transactions would have been identified as cost-effective resources to be acquired under the integrated resource plan.

Recovery by the Distribution Companies of DSM Costs through Electric Rates

There are two mechanisms for recovering the costs of DSM in electric rates: expensing and ratebasing. When the cost of DSM is expensed, the utility recovers 100 percent of the cost of the program during a short period of time, typically one year. When the cost of DSM is ratebased, the cost is capitalized (listed as a utility investment) for a period that approximates the useful life of the DSM measure and then the full cost, plus an allowed rate of return, is amortized and partially recovered each year until the full cost is recovered. In both cases, the costs are recovered from electric customers through rates. Whichever method is used in Poland, the distribution companies should have the authority to invest in DSM and recover the costs of those investments in electric rates.

Discussions with representatives of the Polish electric industry revealed that the negative impact that DSM expenditures could have on revenues and profits may be a substantial deterrent to DSM implementation. In the U.S., utilities are increasingly able to recover as

program costs the lost revenues from reduced consumption caused by the implementation of DSM. Therefore, the distribution companies could also be allowed to recover revenue losses from qualifying DSM expenditures (those expenditures associated with DSM programs that meet minimum qualifications or performance criteria).

The costs of DSM need not be shared equally among all customers of the distribution companies. For example, it may be decided that the costs of industrial DSM programs should only be charged to industrial customers. Those distributions companies with a higher share of their load from industry would then have more of the costs of DSM charged through the industrial rates.

Ability of the Distribution Companies to Earn Financial Incentives to Implement DSM

For many years, state regulatory commissions in the U.S. exhorted electric utilities to increase their DSM expenditures without providing the utilities any financial incentives to do so. In fact, for most utilities, DSM was undesirable because it resulted in lower revenues and profits. This situation has changed. Many states now provide positive financial incentives to utilities to invest in DSM.

These incentives take many forms. For example, some states set specific performance targets (such as for cost-effectiveness and program participation rates), and then offer financial rewards through subsequent rate increases. Other states allow utilities to ratebase their expenditures and then earn a higher than normal rate of return on that investment. Other states provide utilities a share of the total resource savings achieved by their DSM programs. Experimentation continues with many alternative approaches to rewarding utilities for acquiring cost-effective DSM resources.

Regulators generally believe that such rewards are appropriate to compensate utilities for the increased risks of doing something new and relatively untested, such as implementing DSM programs. For the same reason, utilities in Poland could earn financial incentives for implementing DSM consistent with the integrated resource plan.

Without cost recovery and financial incentives, DSM (particularly DSM that focuses on reductions in energy use) is unconventional and antithetical to the normal utility course of business. For many utilities throughout the world, DSM is the opposite of what they think they should be doing. Poland will probably be no different than the rest of the world in this respect. Even if IRP is adopted in Poland, there will likely be utility resistance to DSM activities, at least until utilities learn how to implement DSM programs and appreciate their

benefits. Nonetheless, failure by any distribution company to implement the DSM programs recommended by the integrated resource plan will raise system-wide costs, even for those distribution companies that implement DSM programs.

It is difficult to judge how receptive each of the distribution companies will be to implementing the integrated resource plan's recommended DSM activities. It may be necessary to institute a mechanism that will dissuade distribution companies from refusing to participate. A possible mechanism would be a surcharge that could be added to the wholesale electric rates charged to the non-participating utility. The surcharge could be set equal to an estimate of the additional costs imposed on the national system as a result of the utility's failure to participate.

Regulatory incentive approaches in the U.S. provide a comparable mechanism in the form of a penalty for utilities that implement DSM programs that fail to meet pre-established performance criteria. Such an approach is probably premature in Poland; however, the surcharge for non-participation may be appropriate. Nonetheless, assessing a surcharge is reminiscent of the old central planning mentality and thus, may unnecessarily raise opposition to DSM by the distribution companies.

Provision for Public Involvement

Public involvement is an essential element of IRP. Ratepayers, electric utilities, generating companies, DSM equipment manufacturers and vendors, environmental interests, and the organizations that represent them should be involved throughout the process of developing and implementing a plan. Although public involvement will surely slow the process initially, the process and plan will be better for it, and the political support for the plan will be broader and stronger in the long run. Public hearings, solicitation of written comments, and procedures for adjudicating public disputes with the plan could be provided. Thus, a commitment to broad public participation could be made explicit in energy law or regulations.

5.3 PROVING THE RESOURCE: DESIGNING A PILOT PROJECT

While the formulation and implementation of a regulatory framework is a necessary foundation for the subsequent development of demand-side resources, further information on customer response to DSM, training of Polish utility staff, and technical proof of concept are

all required if widespread implementation is to take place. A pilot DSM project can accomplish all of these objectives.

Because the industrial sector offers both the greatest achievable savings potential as well as the most cost-effective programs, it is the primary candidate for a pilot project. Part 2 of this report presents in detail a DSM pilot project suitable for the industrial sector in Poland.