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BURNS AND ROE ENTERPRISES, INC.

DEMAND SIDE MANGEMENT PROGRAM FOR THE REPUBLIC OF ARMENIA

DELIVERY ORDER No. 28
Hydro/Thermal Power Rehabilitation Feasibility Reports

ARMENIA

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List of Abbreviations

AC	Air conditioner
AC/AEE	Armenian Chapter of the Association of Energy Engineers
A&E	Architect and Engineering Firm
BREI	Burns and Roe Enterprises
CFL	Compact Fluorescent Lamp
DHS	District Heating System
DSM	Demand Side Management
Dr	Dram (Armenian currency, exchange rate 500 drams = 1 US dollar-August 1998)
EE	Eastern Europe
EBRD	European Bank of Reconstruction and Development
EEU	Energy Efficiency Unit of the EBRD
ERC	Energy Regulatory Commission
ESCO	Energy Service Company
EU	European Union
FSU	Former Soviet Union
Gcal	Giga-calorie
GEF	Global Environmental Facility
GOA	Government of Armenia
KW	Kilo Watt
MEF	Ministry of Energy (Government of Armenia)
NEAP	National Environmental Action Plan
OPIC	Overseas Private Investment Corporation
RMA	Resource Management Associates of Madison, Inc
RA	Republic of Armenia
TACIS	Technical Assistance-Commonwealth of Independent States(European AID Agency)
TOU	Time of Use
TV	Television
T&D	Transmission and Distribution
USAID	United States Agency for International Development
USEA	United States Energy Association
USEIA	United States Energy Information Agency
USGS	United States Geological Survey
VSD	Variable Speed Drive
YCLCO	Yerevan City Lighting Company
YDC	Yerevan Distribution Company

EXECUTIVE SUMMARY

Introduction

There is currently sufficient electrical generation capacity in Armenia for meeting its low electricity demands [1] However, the peak electricity demand, driven primarily by electric space and water heating loads, is already putting severe pressure on the electric power system Once the industrial sector, which is currently paralyzed due to shrinking markets for their products, regains its financial viability, still higher electricity demands will cause additional stress on the system [2] Furthermore, the Government of Armenia plans to close down its nuclear power plant by the year 2005, which will result in an increased gap between demand and supply

As further transition toward a market-based economy occurs in the country, substantial changes in the energy infrastructure will be required [3] The electricity sector has started making progress in the right direction with structural, legislative and regulatory reforms, and a privatization program [4] However, high electricity intensities in all sectors need to be reduced in order to restore Armenia's competitiveness Measures to improve energy efficiency -- both in the supply and the demand side -- are vital and need to be addressed by the policy makers

The US Agency for International Development (USAID) provided funding to assess various supply and demand options in the power sector Resource Management Associates of Madison, Inc (RMA) was contracted to explore and assess the opportunities for energy efficiency improvements on the demand-side in the electric power sector of Armenia

[1] Armenia's total electricity generation in 1990 was over 10,000 GWh In the first half of 1990s following the break up of the Soviet Union, it plummeted to an acutely low level of 3 218 GWh in 1994 Electricity was typically supplied to most customers (except critical enterprises such as hospitals, bakeries transport and water utilities) only for less than two hours per day, while there was no gas supply or central heating The reduction has been dramatic in the industrial sector, where demand fell from 4,554 GWh in 1988 to a low 583 GWh in 1993 (Ministry of Energy August 1997) In 1997, total electricity generation was still below 6 000 GWh

[2] Oil gas, and nuclear fuel for power generation are all imported at present

[3] During the Soviet period, Armenia s electricity industry was developed as a part of the integrated Trans-Caucasian Power Network which coordinated power supply among Armenia Azerbaijan and Georgia The system-wide perspective tended to disregard the country-specific energy resources in favor of regional supply objectives As a result, natural gas fired plants were built in Armenia even though the country had to fully rely on imported fuel, mainly from Turkmenistan (Ministry of Energy, August 1997)

[4] According to Government estimates, a total of US$1 7 billion are required for rehabilitation of the entire energy sector, which could prevent the potentially huge technical problems and ensure uninterrupted operation of the system (Noyan-Tapan, 1998)

This report highlights the importance of end-use energy efficiency in Armenia's electric power sector, and identifies areas where cost-effective Demand Side Management (DSM) measures could be implemented The supply and demand situation is examined in detail, and the barriers and driving factors are analyzed for alternative DSM options Recommendations are provided for short- and long-term strategies to facilitate DSM implementation in Armenia Some financing strategies, required in the short-term to make DSM viable, and in the long-term to make them sustainable, are also suggested

In Armenia, there are many institutions and organizations that could play key roles in implementing energy efficiency projects and programs These include the government, energy sector entities, educational institutions, donor agencies, and the private sector At this time, there is no specific organization responsible for energy efficiency development and implementation, although there is an Energy Efficiency Law being considered by the Parliament The Law does not specifically address the issue of how energy efficiency would be implemented through DSM or otherwise However, awareness about these issues exists among the policy makers

Benefits of Demand-Side Management

In addition to the general advantages of energy efficiency through DSM (such as higher cost-effectiveness, higher reliability, reduced environmental impacts, and elimination of high transmission and distribution losses), DSM has the specific benefits for Armenia driven by the following

- Armenia has few or no fossil fuel resources of its own, although it does have hydroelectric and nuclear generating capacities The risk of fuel supply uncertainties for Armenia's thermal power plants exist Imports could be blocked or sabotaged as a result of regional conflicts, whether directly involving Armenia or not In fact, this has been the case in Armenia for some years, and provided compelling reason for restarting the nuclear power station

- The Armenian Nuclear Power Plant (Medzamor), which accounts for a substantial share of the electricity supply, is considered to be a potential environmental hazard of great magnitude This creates a potential risk for Armenia and in the region, and could result in the power plant being closed down at anytime Because of this and the age of the power station, Medzamor is planned for retirement in the year 2005, thereby creating the need for additional supply facilities to meet the existing and rising future demand

- Currently, the complex and somewhat problematic situation in Armenia's electric power system is reflected in the generation and load characteristics In the winter, nuclear power station generation of about 375 MW contributes nearly half of the night-time load of about 800 MW Thus, a night-time accident can have unexpected consequences for the entire system The Hrazdan thermal power plant, which must continue working in the base load conditions because of expensive cold-starts, and to maintain system reliability, results in higher fuel expenditure and lower power system efficiency

- During the summer season, the base load (night-time) falls to below 400 MW The nuclear power plant is run at 180 MW during this time, resulting in power production cost 3 5 times higher than if it would have generated 390 MW (because it could take advantage of re-fueling with one full load) On a summer night, the thermal power plant also uses only 30% of its capacity, which is inefficient from the system's point of view

- Armenia's neighbors, such as Georgia, Turkey and Iran, are potentially large markets for electricity exports Several sources reported the possibility of a 500 kV Regional Power Pool (Grid) within the Black Sea Region-Caucasus being formed in the future, thereby creating an export market for Armenia's electricity Ignoring political considerations, Turkey could be a profitable electricity market at off-peak load

Electricity Demand Characteristics

The residential sector currently contributes the most to electricity demand (see *Table below*) Because of the limited availability of district heating and natural gas, residential customers rely more heavily on electricity for space heating, water heating and cooking This results in a higher share for the residential sector than would normally be the case

Sectoral Electricity Consumption Characteristics

End-Use Category (Units)	*Year*	
	1996	**1997**
Total Consumption (GWh)	4518	4528
Agriculture (%)	6 7	4 8
Transport (%)	3 8	3 2
Industrial (%)	18 0	14 5
Residential (%)	45 1	46 8
Others (%)	23 6	27 3
Exports (%)	2 8	3 4

Note "Others" includes water and sewage pumping systems, street lighting and electricity usage in the commercial sector government buildings, schools and hospitals etc

Residential End-Use Survey

In order to develop more reliable and useful electricity distribution and end-use load data, and to estimate the customer response to a possible residential Day/Night tariff system, an electricity end-use saturation survey of Yerevan's residential customers (a sample of 1,000 apartment units) was carried out under this project The results of this survey are presented in Appendix-I

The comparison of electricity uses in the winter and summer obtained through the surveys of 1000 dwellings are summarized in the table below

Weighted Average Electricity Use by Appliance Type

	Winter	Summer
Space Heating	42%	Not Applicable = Seasonal Saving
Electric Stove	13%	12%
Lighting	12%	6%
Hot Water Heating	11%	8%
Refrigeration	10%	17%
TV	7%	6%
Ironing	2%	2%
Other	3%	3%

Lighting, hot water heating, and refrigeration are the only appliances that have substantial differences between summer and winter use (subtracting out winter space-heating requirements) The differences in lighting and refrigeration can be easily explained by seasonal variation - longer daylight hours in the summer, warmer temperatures (in winter, some items are stored on outside balconies, rather than in refrigerators) The difference in hot water heating in the summer may be due to lower requirements for clothes washing, and to fewer hot water requirements for bathing

Survey respondents were also asked which appliances they would replace if they had any extra money The most common responses (in order) were TV (30%), refrigerator (20%), washing machine (20%) and other (vacuum cleaner, audio center, etc - total 30%) Approximately 20% of residents did not reply to this question, since they did not anticipate having any extra money for the purchase of new appliances These replacement expectations may have some impact on the selection of potential informational type DSM programs and appliance standards and labeling policies

In the survey, residents were asked if they would shift their use of electricity if given a preferential tariff, and what level of tariff reduction would induce them to shift In all categories, 75% - 85% of the residents said that they would consider shifting their electricity usage to night-time (2300 to 700 hours) if given a preferential tariff Their responses to the level of inducement necessary to influence such a shift is shown in the table that follows

Willingness to Shift Electricity Usage to Night-Time (2300-700 hours) Based on Tariff Level (Percentage of Day-Time Tariff)

	25 Percent	50 Percent	75 Percent
Single-Family	18%	8%	74%
4-6 Story	45%	38%	17%
9-12 Story	36%	45%	20%
14-16 Story	45%	43%	12%

Residents were also asked which usages they would be willing to shift to non-peak times Most often mentioned were bathing, clothes washing, ironing, and cooking Bathing and clothes washing would affect the electricity used in water heating As seen in Section 5 of this Appendix, these are not the highest electricity usages as determined by the survey Together, they account for only 22% (summer) to 26% (winter) of residential electricity use Ironing only consumed 2% of electricity use Furthermore, not all of the usage can be shifted to non-peak hours The uses that have the highest electricity consumption, i e refrigeration and space heating, are the least amenable to shifting their time of use and should perhaps be the focus of energy conservation type DSM programs

The results of this survey of household electricity usage patterns provides information about the importance and nature of various end-uses and potential DSM strategies and programs

Load Management (Load-Shifting) DSM Options

In Armenia, load-shifting options (from day time to night time) meet the objective of being able to run Medzamor nuclear power plant and the Yerevan thermal power plant more efficiently, during night hours, particularly during the summer season Load-shifting type of DSM programs will have to be simple (two-part) due to metering costs They also have to rely primarily on behavioral change or changing the electricity end-use appliance or equipment usage patterns It should be noted here that a voluntary industrial TOU tariff system is already in place, and residential TOU tariffs are being considered [5] However, only 48 industrial consumers (mostly bread factories) are on this day/night tariff system and the impact on the load curve has been minimal thus far (personal communication) [6]

It was evident from the discussions with the Ministry of Energy and other Government agencies that load shifting-type DSM programs are of significance to utilities and policy makers This is primarily driven by the objective of increasing valley load levels which would result in higher generation efficiency and lower generation costs, and increasing exports during peak (day-time) hours A TOU tariff (Day/Night tariff) is therefore an attractive option [7] However, the former

[5] These are day-night tariffs for the high voltage consumers with the low night tariff of 12 drams per kWh during 11pm to 7am

[6] No specific analysis has been done of the load shifting impacts that may have resulted from the voluntary Day/Night tariff However, the general opinion of persons consulted was that there has not been any specific load shifting that could be accounted for by the preferential night tariff This is partly due to the " free-rider" effect, where the bread factories which would have operated at night in any case are taking advantage of the savings (and their electricity bill reduction) without really changing their electricity usage patterns

[7] It should be noted here that the lower generation cost advantages (and perhaps higher export earnings) resulting from the load-shifting (to night-time) by TOU tariff mechanism may be offset to some

objective is so appealing to officials that some proponents of this idea even suggested considering simple valley-filling DSM programs (as compared to load-shifting) The latter option could be incorporated into strategic load growth DSM strategies

Energy Reduction DSM Options

Energy conservation DSM programs (that reduce the amount of electricity for end-uses through efficiency improvements) include energy audits and information, incentives and loans, direct installation, and equipment supplier/vendor programs Unlike load management programs, energy conservation DSM programs almost always require monetary investments, which are paid back in time through savings The investments can be made by the utility or the customer or a third party like an ESCO, and the programs create a market for efficient appliances and equipment ("market pull"), which leads to market transformation

DSM Program Recommendations and Strategies

Based on a detailed analysis of various load management and energy conservation type DSM programs, a list of viable strategies and DSM action plan was developed The table (in the following page) summarizes the various actions and strategies that could be undertaken over the short- and long-term to implement energy efficiency improvements through DSM programs A balanced mix of different programs, end-use technologies, sectors, and strategies would be desirable

In the short-run (up to 2005), the major factors that will drive the choice of DSM strategies and policies are

- Armenia Nuclear Power Plant (Medzamor) will be in operation
- Energy efficiency equipment market is not fully developed
- Relatively smaller electricity export market (due to technological and political barriers)
- High transmission and distribution, and commercial, losses
- Focus of programs will be in Yerevan area

In the long-run (after 2005), the following characteristics of the sector will dictate the mix of DSM programs and strategies

- Armenia Nuclear Power Plant will not be in operation
- Energy efficiency equipment/appliance market will have developed because of market transformation
- A larger export market for electricity will have developed
- Focus of programs will move from Yerevan to other areas of Armenia

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extent by lowered revenues collected from the rate-payers (due to lower night-time tariffs)

In addition to specific DSM program implementation, other complimentary strategies have to be developed through energy policies Some of those energy efficiency policy tools are

- Information Dissemination and Education Strategies to increase awareness
- Compulsory Energy Audits
- Strengthening of Energy Efficiency Standards and Introduction of Labeling System
- Transition to Rational Cost-of-Service Based Tariffs and Collection
- Facilitating ESCO Businesses
- Establishment of a DSM Cell and training of its staff

The analysis done in this project suggests that DSM could become sustainable and prove to be a "win-win" proposition for Armenia

Demand-Side Energy Efficiency Strategies and Recommendations

Primary Objective	Target End-Use Sector	Program Option and Mechanism	Target End-Use Technologies	Government or Utility Benefits	Consumer or Societal Benefits	Program Costs	Implementation Strategies and Possible Financing Mechanisms
Load Management DSM Shifting from Daytime to Nighttime	Residential Low Consumption (Low Income)	Time-of use (Day/Night) Tariff Voluntary	Space Heating, Hot Water Clothes Washing Ironing, Cooking Behavioral Change	1 Savings due to increased nuclear/ thermal generation efficiency 2 Extra power available for sale to neighbors during peak hours	Reduced bills	TOU Metering	1 Meters to be financed by the generation cost savings (and export revenue differentials) to be passed by the GenCos to DisCos 2 Meters to be provided under a World Bank program aiming to providing 1 p meters to 9% Yerevan Residential sector by 2001
	Residential High Consumption (High Income)	Time-of Use (Day/Night) Tariff Voluntary	Hot Water Clothes Washing, Ironing, Cooking Behavioral Change	1 Savings due to increased nuclear/ thermal generation efficiency 2 Extra power available for sale to neighbors during peak hours	Reduced bills	TOU metering	1 Meters to be partly financed by the generation cost savings (and export revenue differentials) and partly to be borne by the customers 2 Meters to be provided under a World Bank program aiming to providing 1 p meters to 9% Yerevan Residential sector by 2001
	Industrial such as bread factories	Time-of Use (Day/Night) Tariff Voluntary	Energy intensive industrial process Move from Peak shift to Off Peak Shift Operation	1 Savings due to increased nuclear/ thermal generation efficiency 2 Extra power available for sale to neighbors during peak hours	1 Reduced production costs 2 Increased competitiveness	TOU Metering	1 3 p meters to be provided to all of Yerevan under a World Bank program 2 ESCO s could provide the 3 p meters with shared savings contract with the customers
	Residential High Consumption (High Income)	Time-of use (Day/Night) Tariff	Hot Water Replacement by Super insulated Heaters	1 Savings due to increased nuclear/ thermal generation efficiency 2 Extra power available for sale to neighbors during peak hours	Reduced bills	1 TOU Metering 2 Appliance Replacement	1 Meters to be financed by the generation cost savings (and export revenue differentials) and appliances to be borne by the customers 2 Meters to be provided under a World Bank program aiming to providing 1 p meters to 9% Yerevan Residential sector by 2001 3 Appliance manufacturer could provide incentives (recovered through increased sales)

	Residential	Rescheduling popular TV programs from evening (peak) to night	TV Behavioral Change	1 Savings due to increased nuclear/ thermal generation efficiency 2 Extra power available for sale to neighbors during peak hours	Reduced Bills		
Strategic Load Growth DSM	Industrial non operational Industries New Industries	Time-of use (Day/Night) Tariff	Industrial processes allow night shift operation only to the reviving industries give night kW load permit only	Savings due to increased nuclear/ thermal generation efficiency	1 Lower bills 2 Increased competitiveness for market	TOU metering	1 Meters to be financed by the generation cost savings (and export revenue differentials) and the cost of appliances to be borne by the customers 2 1 3 p meters to be provided to all of Yerevan under a World Bank program.
Strategic Energy Conservation DSM	Residential Commercial Government, Schools Hospitals	Lighting Appliance Vendor Development (CFL and Fluorescent lamps development)	Lighting	1 Reduced need for adding power plants in the future 2 Extra power available for sale to neighbors during peak and off peak hours	1 Reduced bills 2 Reduced expenses 3 Market Transformation	Vendor incentive	Foreign firms collaborating with local firms and local manufacturers provide the seed money
	Residential	Incentives and Loans	Water Heater Jackets	1 Reduced need for adding power plants in the future 2 Extra power available for sale to neighbors during peak and off peak hours	1 Reduced bills 2 Reduced expenses	Incentive	Incentives to be provided by the utility (distribution company)
	Residential	Information Program (through newspaper and other media)	Refrigerators TV (replacement of old appliances with new ones)	1 Reduced need for adding power plants in the future 2 Extra power available for sale to neighbors during peak and off peak hours	1 Reduced bills 2 Reduced expenses	1 Information program costs 2 Extra cost of efficient appliances	Government should be involved in information dissemination programs e g providing incentives to the media for including the energy efficiency agenda in their programming
	Residential	Direct Installation	Water Heater replacement with Solar Powered Water Heater	1 Reduced need for adding power plants in the future 2 Extra power available for sale to neighbors during peak and off peak hours	1 Reduced bills 2 Reduced expenses	Solar Powered Water Heater Cost	Cost of solar water heater could be paid for by savings arising out of zero electricity consumption. ESCOs could get involved in this financing activity

	Commercial Government Buildings Schools Hospitals	Performance Guarantee/ Shared Savings Programs	Controls Lighting improvements				ESCOs raise the money (through subsidized loans) and install the equipment
	Commercial Schools and Hospitals	Direct Installation	Building Weatherization				Funding could be done through multi lateral development banks and subsidized loans
	Municipalities	Direct Installation	Water Pumping, Street Lighting	1 Reduced need for adding power plants in the future 2 Extra power available for sale to neighbors during peak and off peak hours	1 Reduced expenses of the municipality resulting in lower utility costs for the customers	Replacement Cost	ESCOs raise the money (through subsidized loans) and install the equipment. Investment recovered through performance guarantee based shared savings program.
	Industries	Energy Audits and Information, Incentives	Efficient Motors Variable Speed Drives	1 Reduced need for adding power plants in the future 2 Extra power available for sale to neighbors during peak and off peak hours	1 Reduced Costs 2 Increased competitiveness and larger markets	1 Energy Audit Cost 2 Replacement Cost	Agencies like ACAEE and other ESCOs could get involved in the energy audit actvities and do it free of cost with the assurance that they will be involved in the implementation process
	Industries	Direct Installation or Incentives/Rebates	Capacitors for Power Factor Improvement	1 Reduced need for adding power plants in the future 2 Extra power available for sale to neighbors during peak and off peak hours	1 Reduced Costs	Capacitor Cost	This type of program is expected to have very low paybacks ESCO s could purchase and lease capacitors to customers on a performance guarantee and shared savings basis

I INTRODUCTION

The Government of Armenia, assisted by the U S Agency for International Development (USAID), is investigating options for electricity supply to the Armenian Nuclear Power Plant, which is planned to close down in 2005 Several supply options are being evaluated by Burns and Roe Enterprises (BREI), under contract to USAID (Delivery Order #28, Armenia Power Supply/Conservation Project) This reports looks at the demand-side management (DSM) options for increasing the end-use efficiency in the power system This investigation was done by Resource Management Associates of Madison, Inc (RMA), under subcontract to BREI Much of the Armenian data contained in this analysis was provided by the local counterpart organizations to the DSM study the Ministry of Energy and Fuels - Research and Development Department (Mr Robert Khazarian) and the Energy Strategy Center (Dr Ruben Muradyan) [8]

The structure of the report is as follows In Section 2, there is a discussion of the reasons (or objectives) for implementing DSM – both those objectives that apply broadly across all countries and those that are specific to Armenia This is followed in Section 3 with an analysis of the electricity sector supply and demand characteristics in Armenia, which forms the basis for specific DSM strategies Section 4 presents an analysis of electricity tariffs in Armenia This is followed by Section 5, which includes an overview of the infra-structural and organizational aspects related to energy efficiency development and implementation in Armenia Section 6 focuses on the development of DSM strategies and programs for Armenia Section 7 deals with the heating load and options for replacing some of the electricity demand with rehabilitation of the natural gas and/or district heating systems Section 8 describes options for financing DSM programs, both internally and with external sources of finance The report concludes with a discussion of long-term DSM programs and recommendations (Section 9)

[8] The Ministry has since been renamed to the Ministry of Energy

2 DSM PROGRAM OBJECTIVES

In order for DSM programs to be attractive and have the potential to be successfully implemented, it is necessary first to define clearly the objectives for DSM This section describes the general objectives for implementing DSM that are common to many countries, industrialized, transitional or developed This general description of objectives is followed by a discussion of objectives specific to Armenia, which make the case for Armenia even more compelling

A General Objectives for Implementing DSM

In the United States, Demand-Side Management (DSM) got its start in the late 1970s, mainly as a result of regulatory requirements and pressure from environmental groups The oil crisis of 1973 made Americans aware of the importance of energy in the economy, and innovative strategies began developing which focused on the rational use of energy DSM was a mainly utility-sponsored mechanism through which the use of energy (particularly electricity) and the timing of energy use by end-users (customers) were influenced The utilities designed DSM programs to meet their own objectives of not adding power stations, as well as the broader societal objective of cleaning up the environment Moreover, the technical options that were put in place through DSM programs were cost-effective compared to the supply-side options The utilities could thus share some of the money saved, by not adding more expensive generation capacity, with the end-users in the form of customer incentives to implement DSM State regulators started mandating DSM in early 1980s because these strategies helped customers reduce their energy demand and use, thus saving on energy costs These energy savings reduced the amount of energy an energy provider (such as an electric utility) needs to provide in both the short and long term

B DSM Objectives for Armenia

Armenia's population of about 3 8 million has a per capita electricity consumption of over 1,180 kWh, which is considerably higher than the world average for developing countries The high per capita electricity consumption has, in part, been caused by recent reliance on electricity for meeting residential water heating and winter space heating demand This reliance is common in all economic sectors, with a large effect due to space heating needs in the residential sector, comprised of 750,000 formerly state-owned, but currently privatized, residential apartments

The general standard of living is expected to recover gradually from a current low income of US$294 per capita (in 1996) With higher incomes, residential electricity demand will grow in the future as consumers purchase more electrical appliances Demand in other sectors, such as the commercial and industrial sectors, will also grow with an improved economy It is clear that the proper management of the energy industry, particularly the electricity sector, will be a crucial factor in Armenia's continuing economic recovery and future development process

As in other transitional and developing countries, there is enormous potential for efficiency improvement in both the supply and demand components of Armenia's electricity sector A utility's motivation for developing DSM programs will vary, depending on both the economic and energy supply conditions However, the benefits of DSM programs for the utility and the customers are significant under a variety of circumstances In addition to the overall economic and environmental benefits of DSM measures compared to traditional supply-side options, as discussed above, the rationale for implementing DSM in Armenia has numerous compelling benefits

Some of the objectives for implementing DSM in Armenia are common to many transitional and developing countries that have recently adopted it, such as Thailand, Mexico and China These general objectives for implementing DSM are

- DSM measures have higher cost-effectiveness than in the industrialized countries because of higher savings potential and higher share of energy costs (over total costs and expenditures)
- DSM could effectively reduce the relatively faster growth of electricity needs (both kW and kWh)
- Scarcity of capital required for adding supply-side resources makes DSM options more attractive Supply options generally range from US$800 - $3,000 per kW, compared to DSM cost of US$400 per kW on average [9]
- DSM often helps improve peak reliability of the system, thereby reducing the need for electricity rationing and/or blackouts
- DSM helps reduce demand, eliminating the need for power flow over the transmission and distribution (T&D) network, thus creating savings in generally high T&D losses associated with power flow If 1 kW is saved at the end-user level through DSM, it in fact results in about 1 2 kW savings at the production level This objective is particularly relevant for Armenia because electric energy losses over the T&D networks are very high, as shown in *Table 2 1* [10]

Table 2 1
Transmission and Distribution (T&D) Losses

Year	1988	1993	1994	1996	1997	1998
T&D Loss (%)	14 5	20 1	23 06	18 57	18 5	18 1

Source Ministry of Energy (April 1998)

- Environmental benefits of DSM are considerable, and especially valuable to society, when controls are not in place to mitigate pollution from supply-side sources This is the case in Armenia, where the power sector is in poor financial health and cannot afford expensive pollution controls

[9] Armenia's supply capacity seems to be sufficient to meet the present demand But, as demand increases over the next decades there will be a growing need for adding new power plants The high costs associated with this anticipated expansion could be cost-effectively reduced through implementation of DSM options

[10] According to recent Government estimates, currently the technological losses alone in the energy sector total 18 5% which is equivalent to 22 billion drams (US$44 million) annually (Noyan-Tapan, 1998) The commercial losses are also quite substantial However, the Armenian Government is currently focusing largely on regulation of energy tariffs and enforcement of billing and bill collection discipline including dis-connections due to non-payments, which have led to increase in total collections from 35% in 1994 to 80% in 1998, resulting is reduction of commercial losses

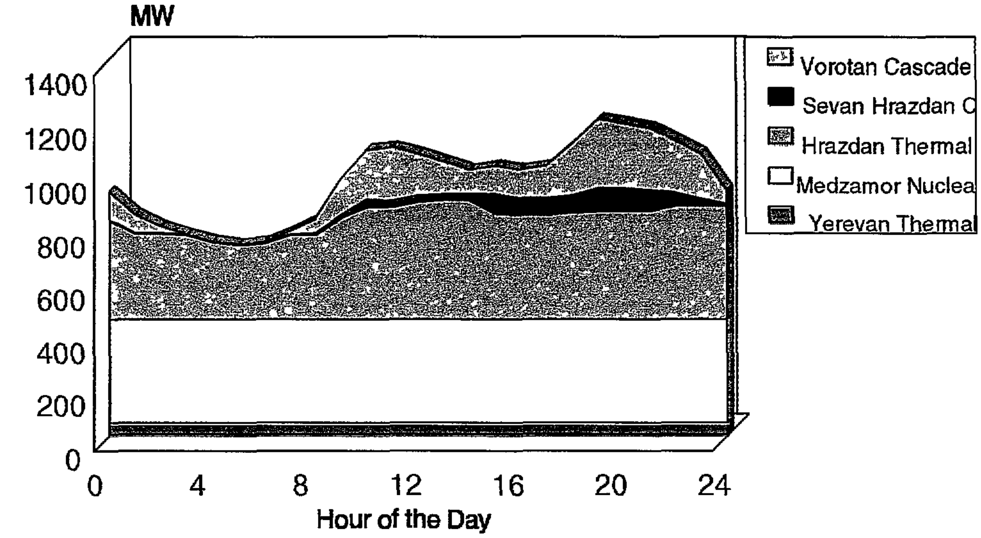
In addition to these general benefits for transitional economies, five other driving factors support the promotion of DSM specifically in the Armenian electric power sector

- Lack of Indigenous Energy Supplies Armenia has few or no fossil fuel resources of its own, although it does have hydroelectric and nuclear generating capacities (USEIA, 1996) The Armenian Ministry of Underground Resources, in cooperation with the US Geological Survey (USGS), has also been exploring the quantity and quality of coal reserves in Armenia No studies have yet been done of the cost-effectiveness of using these reserves for power generation Thus overall, the risk of fuel supply uncertainties for Armenia's thermal power plants exist Imports could be blocked or sabotaged as a result of regional conflicts, whether directly involving Armenia or not In fact, this has been the case in Armenia for some years, and provided compelling reason for restarting the nuclear power station

- Nuclear Power Plant Risk The Armenian Nuclear Power Plant (Medzamor), which accounts for a substantial share of the electricity supply, is considered to be a potential environmental hazard of great magnitude This creates a potential risk for Armenia and in the region, and could result in the power plant being closed down at anytime Because of this and the age of the power station, Medzamor is planned for retirement in the year 2005, thereby creating the need for additional supply facilities to meet the existing and rising future demand

- Power System Efficiency and Reliability Currently, the complex and somewhat problematic situation in Armenia's electric power system is reflected in the generation and load characteristics In the winter, nuclear power station generation of about 375 MW contributes nearly half of the night-time load of about 800 MW Thus, a night-time accident can have unexpected consequences for the entire system The Hrazdan thermal power plant, which must continue working in the base load conditions because of expensive cold-starts, and to maintain system reliability, results in higher fuel expenditure and lower power system efficiency *Figure 2 1* illustrates a typical characteristic winter day supply and load Shifting the peak loads to off-peak (night-time) hours will enable operating both the nuclear and the thermal units during off-peak hours closer to their full capacities and, therefore, more efficiently Load management aimed at flattening the load curve (load shifting) is of vital importance for other reasons as well

Figure 2 1
Daily Characteristics of Winter Electricity Generation in Armenia



Source Ministry of Energy (April 1998)

Power Production Costs During the summer season, the base load (night-time) falls to below 400 MW The nuclear power plant is run at 180 MW during this time, resulting in power production cost 3 5 times higher than if it would have generated 390 MW (because it could take advantage of re-fueling with one full load) On a summer night, the thermal power plant also uses only 30% of its capacity, which is inefficient from the system's point of view Thus a load-shifting type DSM program would be advantageous in being able to offset the revenue loss resulting from the difference in night and day tariffs with lowered generation costs [11] This "flattening" of the load curve through load shifting can be done through DSM mechanisms or through pumped hydro storage, where electricity produced at the nuclear power plant during the night will be stored for use during the day time However, a feasibility study shows that one 100MW, 1 million cubic-meters, pumped-hydro storage unit with a 60% efficiency will cost $41 million and pay back period will be 5 6 years (personal communication) Comparatively, DSM options will have much lower payback periods of 1-2 years

- ***Export Potential*** Armenia's neighbors, such as Georgia, Turkey and Iran, are potentially large markets for electricity exports [12] There is a caveat that, although exporting power could be one

[11] For the current voluntary TOU tariff system, the rate is 21 Drams per kWh in the daytime and 12 Drams at night-time

[12] Presently Armenia is connected with neighboring countries by 330-220-110 kV inter-system lines The ring-shaped network forming the system has sufficient capacity and is able to provide transit and inter-system flows of electric energy However, existing 110 kV interconnections with neighbors, Georgia, Azerbaijan and Turkey, are not in operation A new 220 kV Double Circuit Transmission Line that is being built between Armenia and Iran, was placed in service in early 1997 and can carry about 65 MW (Ministry of Energy, August 1997)

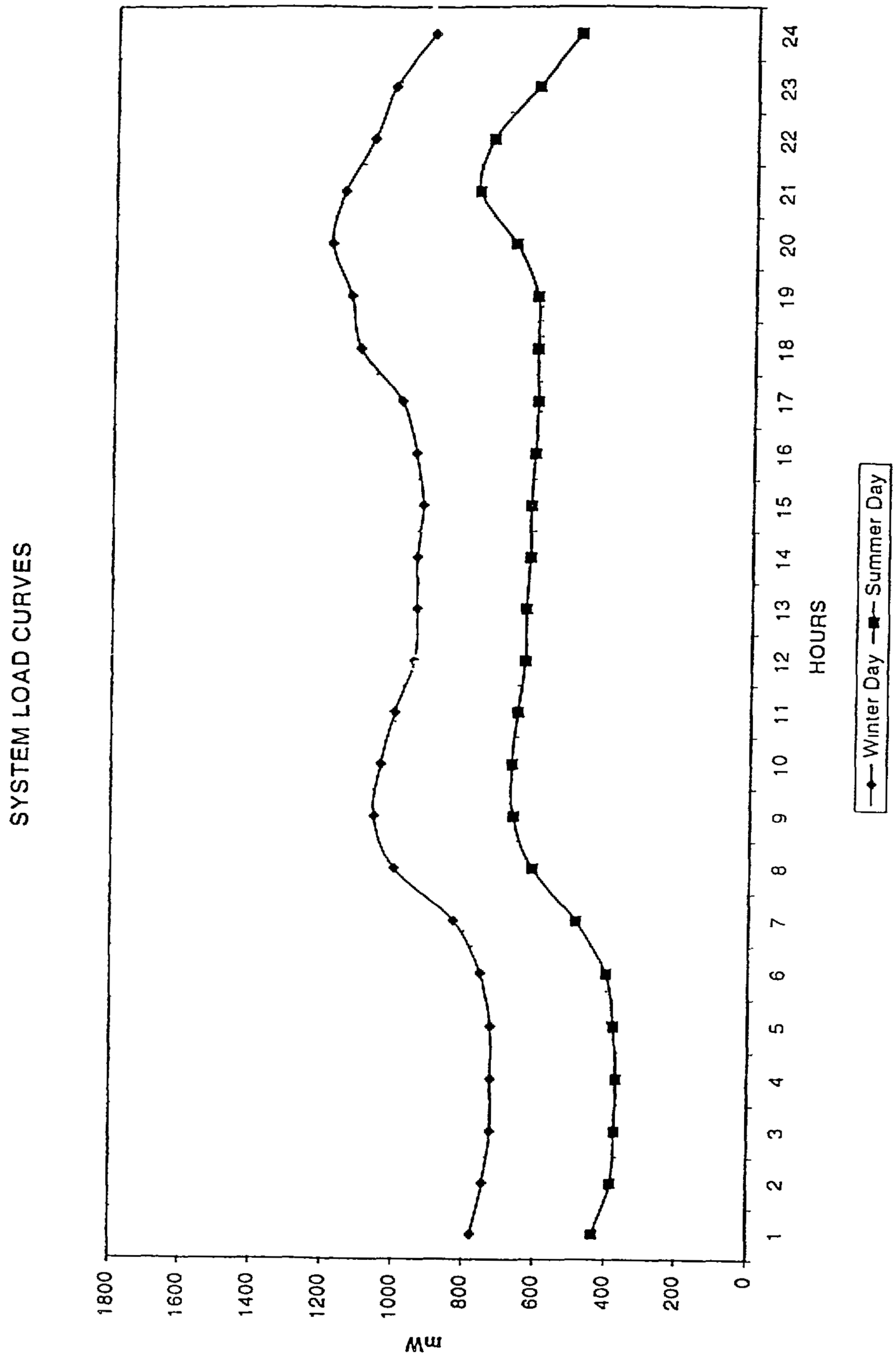
of the major attractions of implementing energy efficiency programs through DSM, only Georgia is currently a viable export market in the short run But, Georgia also has limited financial resources to pay for the imported electricity Several sources reported the possibility of a 500 kV Regional Power Pool (Grid) within the Black Sea Region-Caucasus being formed in the future, thereby creating an export market for Armenia's electricity Ignoring political considerations, Turkey could be a profitable electricity market at off-peak load Turkey is ready to buy electricity at 3 cents/kWh at night, their own cost of supply This potential export market exists because Turkey has an annual growth rate of 8 percent, and they are currently purchasing power from Bulgaria at 3 5 cents per kWh

3 ELECTRICITY SUPPLY AND DEMAND ANALYSIS

In order to identify cost-effective DSM programs and implementation mechanisms, it is necessary to analyze the customer profiles, or end-use load curves Ideally, enough information is available about customer energy end-uses and timing of demand to pinpoint which DSM programs will meet the utility-determined objectives (kW and kWh reductions) Utility capacity requirements forecasting begins with a sector-by-sector look at the components of the base and peak -load requirements This data is gathered primarily from customer billing records, which are a reliable source of end-use demand data

In the case of Armenia, historical end-use data based on electricity consumption (billing records) by sectors was not available It was necessary to infer end-use data from a variety of sources Hourly electricity generation data for all of Armenia was provided (by consultants under another USAID project) for the full year of 1997 (365 days) This is generation or system load data, as produced by the power plants, and given in Appendix II To illustrate this data, a typical winter and summer day (February 10, 1997 and August 10, 1997) are displayed in *Figure 3 1* Typically these curves are referred to as "load curves," however, since these curves represent the generation data, they should be referred to as "system load curves " As the figure illustrates, electrical generation varies during the day in response to the electrical demand of the country The figure also shows that the data for the winter and summer are quite different in magnitude This aspect will be discussed later in this section

Figure 3 1
Summer and Winter Sample Load Curves



A Generation

The restructuring of the once vertically-integrated monopoly state enterprise *Haienergo* (Armenergo) in 1996 resulted in unbundling of its generation, transmission and distribution functions to commercial trading entities amenable to a market-based electricity industry Privatization of these entities is also currently under way, as legislated by the new Energy Regulatory Law of 1997 [13] At present, there are six major generation supply enterprises Hrazdan Thermal (1,110 MW), Yerevan Thermal (550 MW), Vanadzor Thermal (96 MW), Sevan-Hrazdan Hydro Cascade (532 MW), Vorotan Hydro Cascade (456 MW), Medzamor Nuclear (450 MW), and some other small generators

However, in analyzing the electrical demand curves, it is important to also understand the actual generation situation and how the system generation and demand interact The following passage is taken from "Volume A Rehabilitation and Restructuring Plan for the Armenian Electrical Sector," prepared by *EnergyInvest PIO* (Ministry of Energy, August 1997)

> "At present, Armenia's generating capacity consists of a nuclear power plant, three large thermal power plants, two hydroelectric cascades and numerous smaller resources Installed capacity totals almost 3,500 MW, however, operable capacity is limited to about 1,700 MW Fuel and water constraints further limit available capacity such that on any given day, about 1,000 MW are available "

This report further states that the Medzamor nuclear power plant has an operational capacity of 440 MW Therefore, the non-nuclear daily capacity is about 560 to 1260 MW

As *Figure 3 2* indicates, the summer electrical demand[14] varies from a low of about 375 MW to a peak of around 800 MW The winter day has two periods that are above the 1000 MW value, peaking around 1200 MW The peak day (New Year's Eve) shows loads well in excess of the 1000 MW level Based on the previous statement regarding the difficulty of providing power for loads above 1000 MW, the need to reduce the electrical load, especially in the winter, becomes apparent *Figure 3 2* also shows that the winter load completely exceeds the non-nuclear available capacity of 560 MW by an average of 300 to 400 MW, while the summer load also exceeds the 560 MW level Therefore, in view of the non-availability of nuclear generation due to expected closing of the nuclear power plant (Medzamor) in 2005, a distinct possibility of electricity shortage exists DSM thus becomes an attractive alternative for avoiding an electricity crisis Supplying the current system load is already a significant challenge, since much of the generating capacity is unreliable Meeting new customer demand is an even greater challenge when the system cannot reliably meet all of its current load

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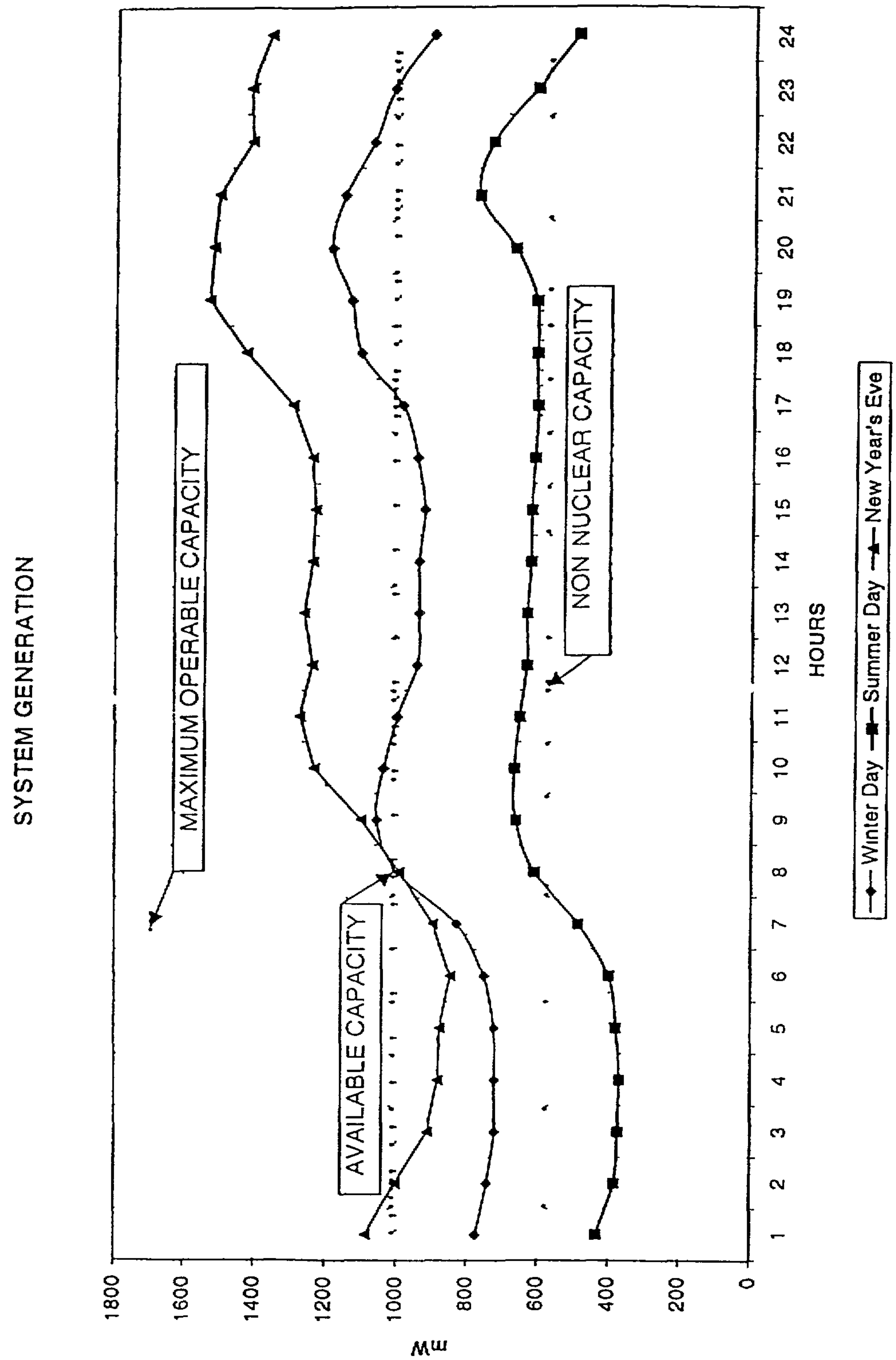
[13] This fuel switch was influenced in part by dwindling residential gas supplies and by a poorly functioning central heating system

[14] Unless otherwise noted in the following discussions demand refers to system load (that is, includes system losses)

Figure 3 2

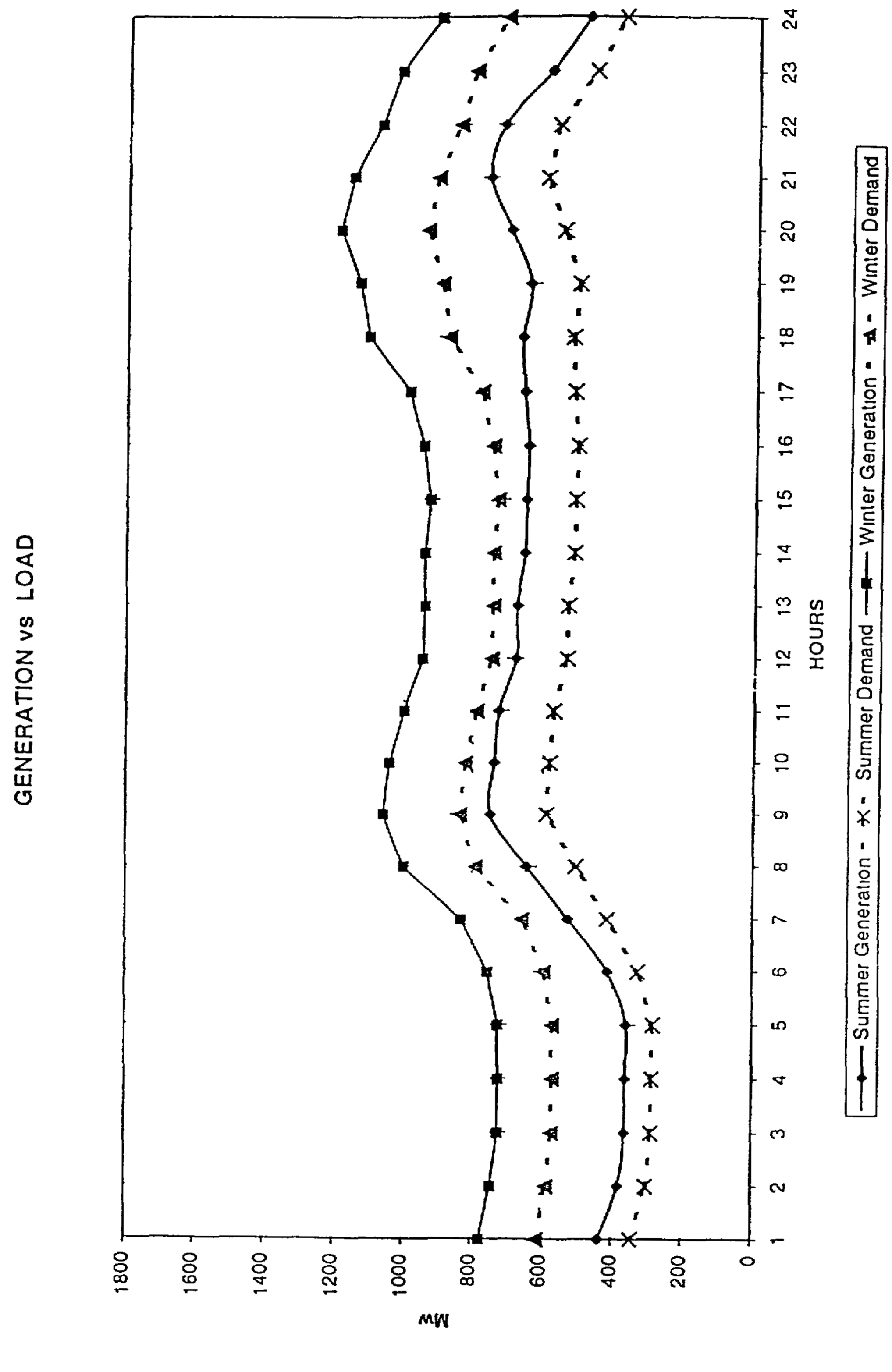

SYSTEM GENERATION
MAXIMUM OPERABLE CAPACITY
AVAILABLE CAPACITY
NON NUCLEAR CAPACITY
mW
1800
1600
1400
1200
1000
800
600
400
200
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
HOURS
Winter Day
Summer Day
New Year's Eve

The discussion that follows is an analysis of the generation data, what the data indicates regarding users, and the potential for reducing the customer load The significance of the currently reliable generating capacity versus the hourly load curves is also shown in *Figure 3 2*

B Transmission and Distribution Losses

The data presented in Fig 3 1 and Fig 3 2 includes not only the customer (end-user) load but also all of the system losses resulting from transmission and distribution to the customers To analyze customer-only loads, the losses must first be removed from the system load data Transmission and distribution (T & D) losses have ranged from 18 to 23 percent over the past ten years (see Table 2 1), and have averaged about 21 percent for the past several years using this 21 percent average, the actual customer load was estimated from the system load data as shown in Fig 3 3 Typical summer and winter days displayed in Fig 3 3 are July 15 and February 10, 1997 The T&D losses are significant, amounting to roughly 100 to 150 MW each hour during the summer and approximately 200 MW per hour during the winter These numbers become even more significant when compared to the reliable non-nuclear generation, which is only 560 MW These losses are more than double the typical T & D losses in developed countries, which are more typically in the range of 7-9 percent While it is not possible to completely eliminate T&D losses, if the losses could be halved, the result would be similar to gaining an extra 50 to 100 MW of capacity This is a common problem and solution in other developing countries also The Armenian energy sector professionals are also aware of this problem, and it is clear that the elimination of excess T&D losses is their high priority, as demonstrated by their negotiations with the World Bank and the Japanese Government for loans to rehabilitate the T&D system in Yerevan

Figure 3 3


GENERATION vs LOAD
Mw
1800
1600
1400
1200
1000
800
600
400
200
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
HOURS
Summer Generation
Summer Demand
Winter Generation
Winter Demand

In the discussions that follow, the estimated customer load (generation adjusted for 21 percent T&D losses) is used in the demand analysis and the subsequent analysis of demand-side management (DSM) targets and strategies

C Demand Analysis

To obtain a clear understanding of the customer demand, the best method is to graph the daily loads hour by hour There are several ways to do this

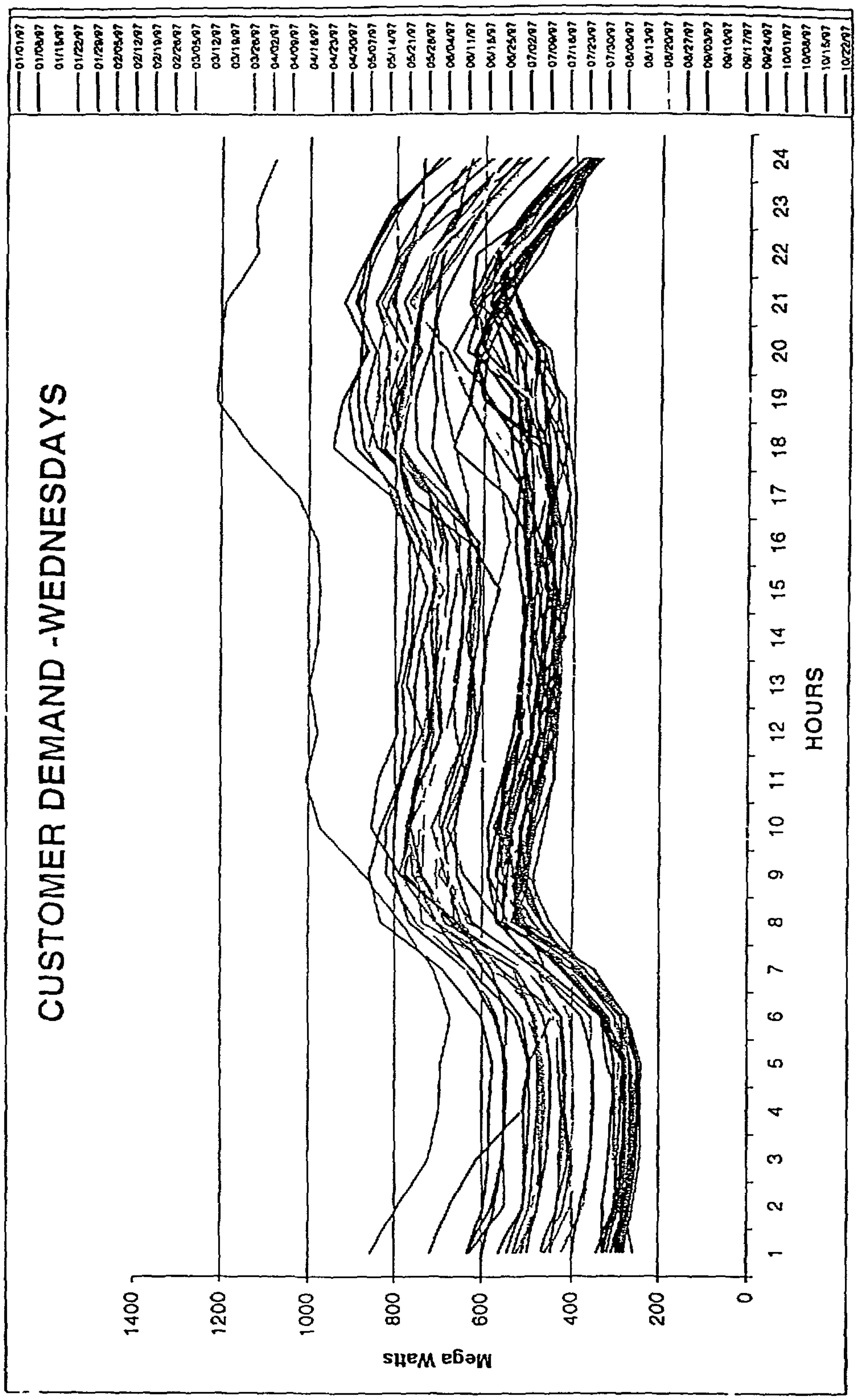
- Ideally, every day of the year could be represented on the same graph, but this is not practical, since the graph would be extremely cluttered and impossible to decipher
- One mid-week (work) day a week for a full year could be selected and then graphed This graph would be best at illustrating seasonal changes
- A week could be selected and each day of the week graphed to illustrate the weekly load changes
- A mid-week (work) day could be graphed against a weekend day (holiday) to illustrate the changes in business and recreation that result during typical weeks

Seasonal Load Variation

Figure 3 4 illustrates the customer load for every Wednesday of 1997 Two main observations are evident from this graph

- The load on New Year's Eve day is substantially higher than any other day
- The graph shows two distinct load bands, one representing the summer period and one representing the winter period

Figure 3 4


CUSTOMER DEMAND -WEDNESDAYS
Mega Watts
1400
1200
1000
800
600
400
200
0
HOURS
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24

The demand curve for New Year's Eve is especially interesting While the shape of this curve is consistent with the other curves, the curve is shifted upward approximately 300 MW from the other winter data From the graph, it appears that this holiday period has the greatest electrical demand This is apparently a phenomenon that is due only to the holiday and is not a regular event

Figure 3 4 makes it obvious that there is a general seasonal increase in electrical demand during the winter months As can be seen, the summer load band has a fairly tight load distribution However, the load for the winter months is not so tightly bunched, and the load varies by as much as 200 MW at any particular hour This variation in the winter electrical load is undoubtedly due to the temperature variations at this time of year In general, however, the winter load exceeds the summer load by 300 to 500 MW

It is easy to see that electricity demand is greatly influenced by the seasons This seasonal increase is obviously due to many factors, among which are increased lighting, due to fewer hours of daylight during the winter, and increased space and water heating needs, due to the colder winter temperatures A large portion of the increase caused by additional heating comes from the individual use of supplemental electric space heaters This reliance on electrical heating is a result of district heating system shut-downs caused by insufficient fuel supplies However, there is likely also a small increase in electricity demand from some operations of the district heating system (in summer, only the domestic water pumps operate, while in winter a small number of the larger district heating pumps are also in operation) In general, electrical usage in winter would be expected to be higher than in the summer months, since the population tends to be indoors more and there is greater use of televisions, radios, and other household electrical equipment

Other factors, such as the use of additional district heating pumps, probably contribute relatively less to the seasonal increase While there certainly are changes occurring in the economy in general, the main reason for the winter shift is increased electric heating It is obvious that this condition places a huge load on an electrical system that was not designed to handle such demand (Ministry of Energy, August 1997) For instance, the total daily energy demand for a typical winter and summer day is shown below

Winter day (2/12/97)	18,173 MWh
Summer day (8/10/97)	10,832 MWh
Difference	7,341 MWh

From these numbers, it can be seen that the seasonal daily difference of 7,341 MWh is two-thirds of the summer demand of 10,832 MWh The magnitude of this difference highlights the need to make this seasonal consumption a primary target for load reduction through DSM strategies

Daily Load Variation

Figure 3 5 examines customer load for a full week to observe any variation from day to day What is striking about this graph is the closeness of all of the curves There is very little variation, even between week days and weekend days There are some differences, especially in the lower peak observed on Saturday, but in general the curves are remarkably similar The significance of this phenomenon will be discussed later

Analysis of Daily Load Curves

The load curves illustrated in *Figures 3 1* through *3 5* all have the same general shape This is true of the data for the entire year, although the curve may be shifted on a seasonal basis Following is a review of the load curves for a typical summer and winter day

Summer Curves The early morning hours are relatively flat, although there is a slight decrease in consumption until 5 am From 5 am, the demand increases to the morning peak of approximately 650 MW between 8 and 9 am The demand is relatively level from 9 am until about 7 pm, when the load increases sharply to the daily peak of over 750 MW at about 9 30 pm After 9 30 pm, the demand decreases sharply until the following morning valley

Winter Curves At 1 am, the electrical demand is decreasing, although the value remains high at almost 800 MW The curve continues to decrease, but begins to level off around 3 30 am at about 700 MW The winter valley is reached between 4 and 5 am at 725 MW From then, the load curve begins to increase rapidly until 9 am, when it starts to fall off The period between 9 am and 12 noon shows a steep decline in electrical consumption From noon until 7 pm the curve is relatively level The demand increases to 1200 MW at 9 pm, when the daily peak is reached The demand remains high but fluctuates for the next three to four hours, then it decreases rapidly

Since the curves have the same general shape, we can illustrate several important aspects of the data by using one day as typical of the data (see *Figure 3 6*) Note that while the values and the specific hours of occurrence may vary from day to day, the general observations hold true First, the lowest load of the day occurs between the hours of 3 and 5 am This is characterized by a valley or low point beginning around 5 or 6 am, then increasing to a morning peak at around 9 am Each day, the load falls off slightly until the early evening, when the load again increases at around 5 to 6 pm The evening load generally remains high until around 9 or 10 pm, when the load again decreases to the early morning valley

Figure 3 5

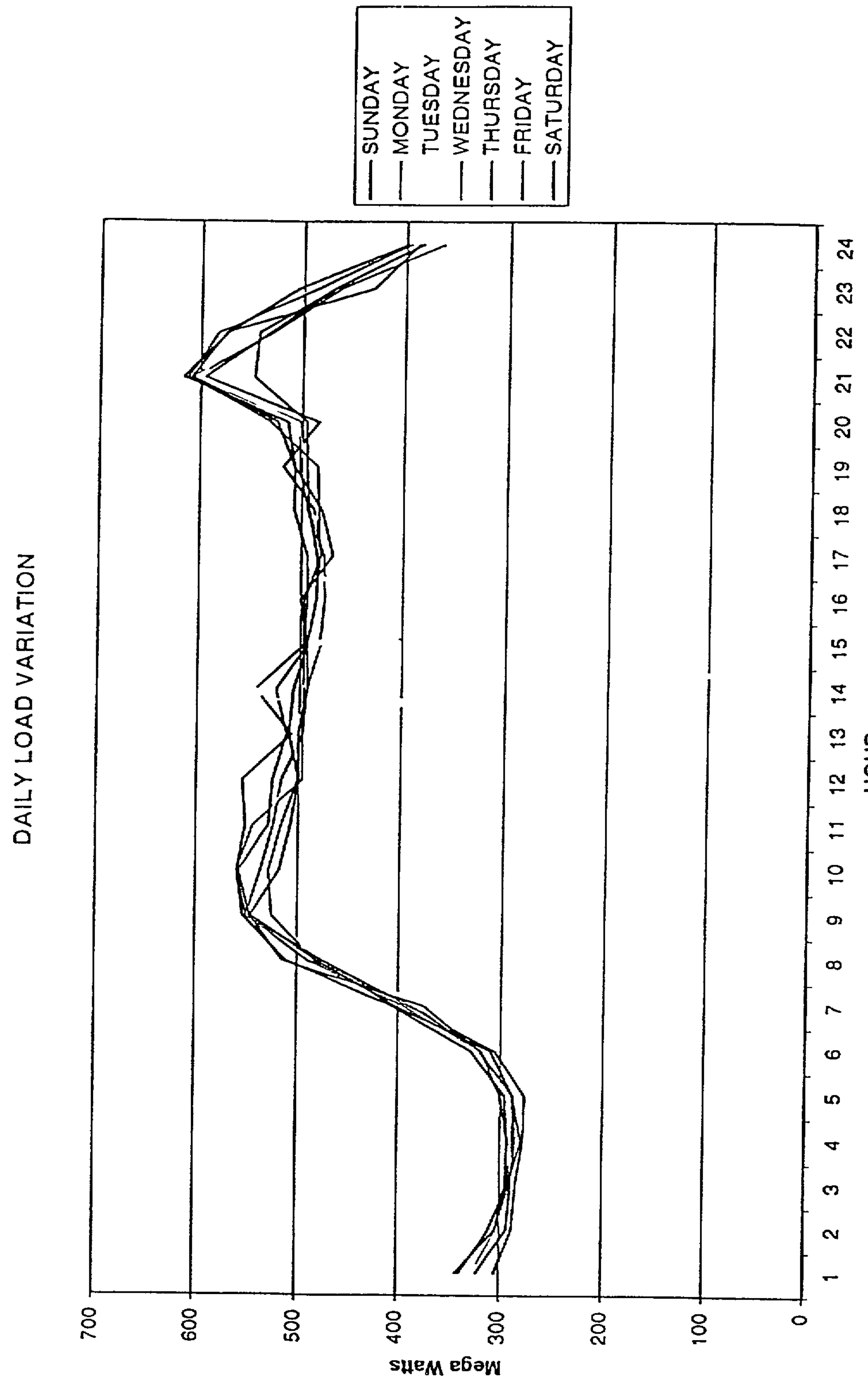

DAILY LOAD VARIATION
SUNDAY
MONDAY
TUESDAY
WEDNESDAY
THURSDAY
FRIDAY
SATURDAY
Mega Watts
700
600
500
400
300
200
100
0
HOUR
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24

Figure 3 6

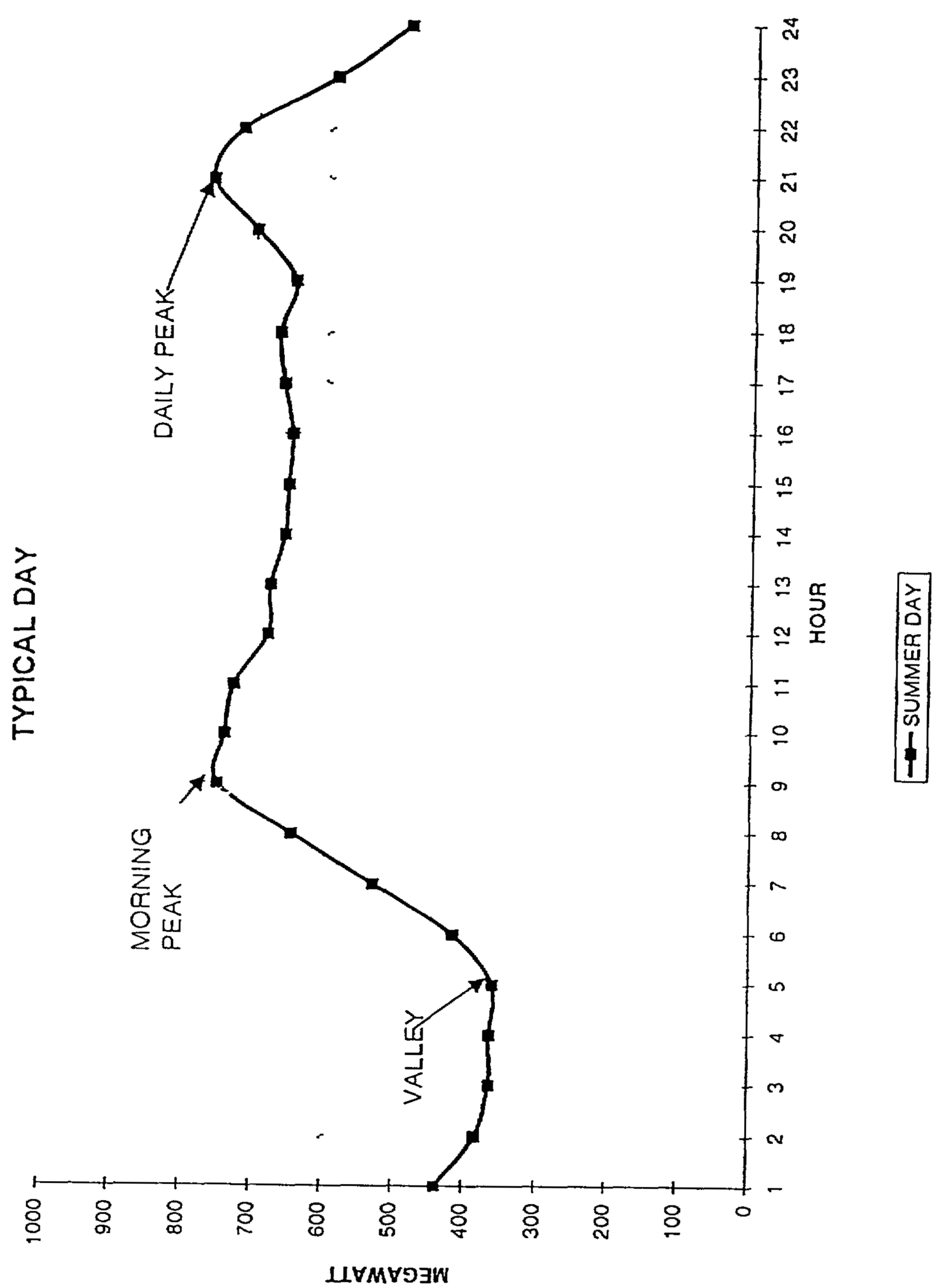
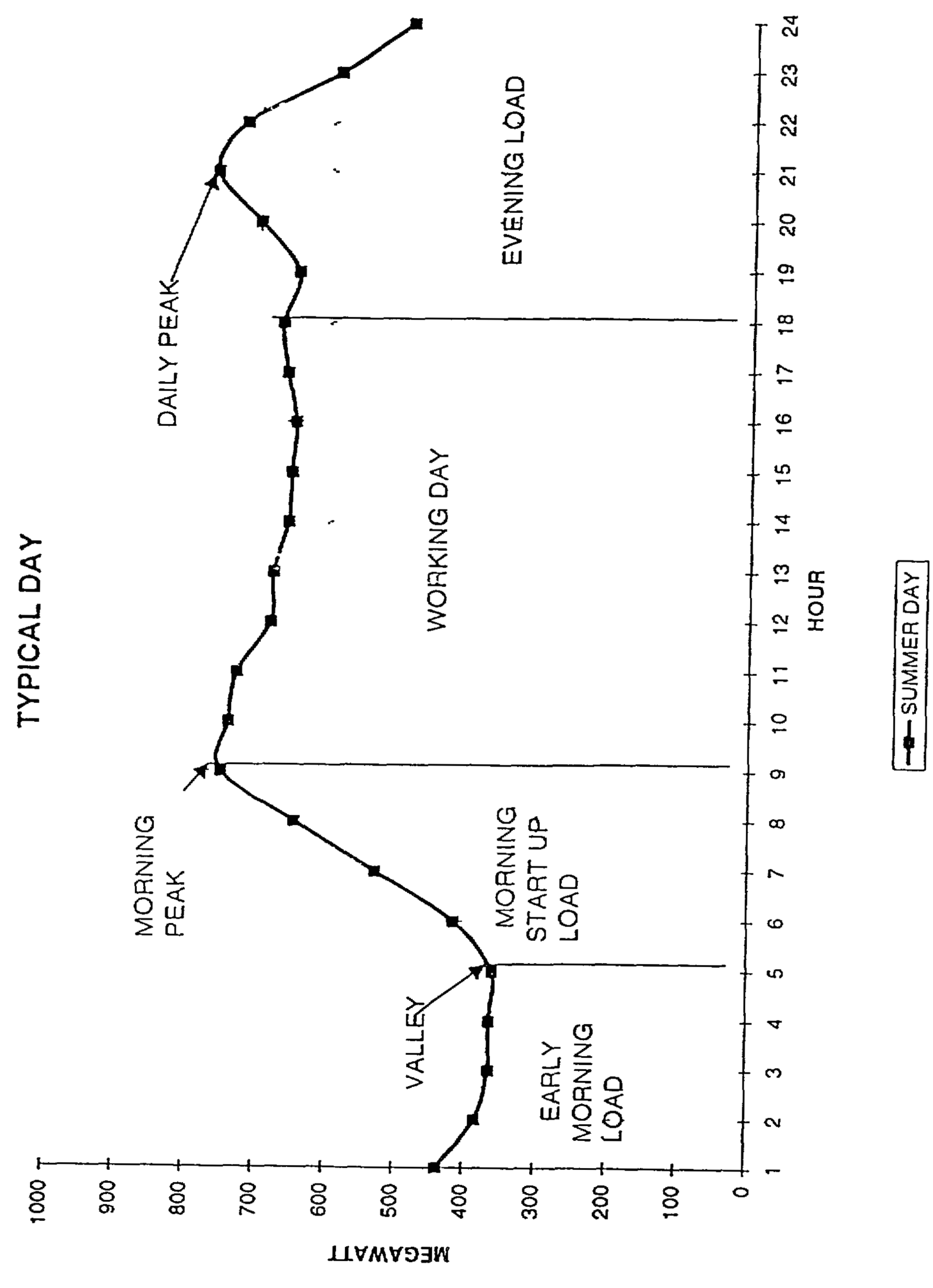

TYPICAL DAY
DAILY PEAK
MORNING PEAK
VALLEY
MEGAWATT
1000
900
800
700
600
500
400
300
200
100
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
HOUR
SUMMER DAY

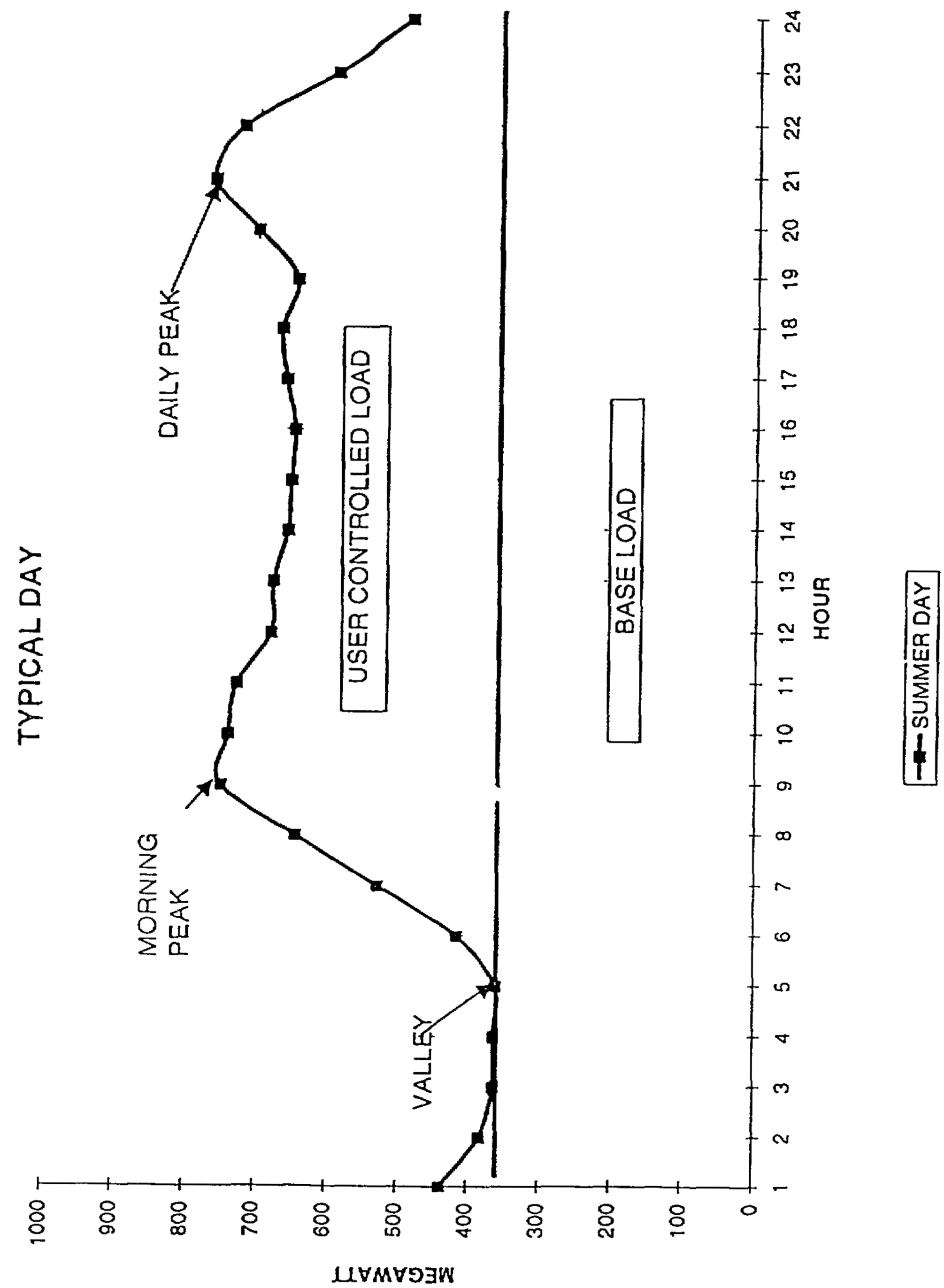
Figure 3 7

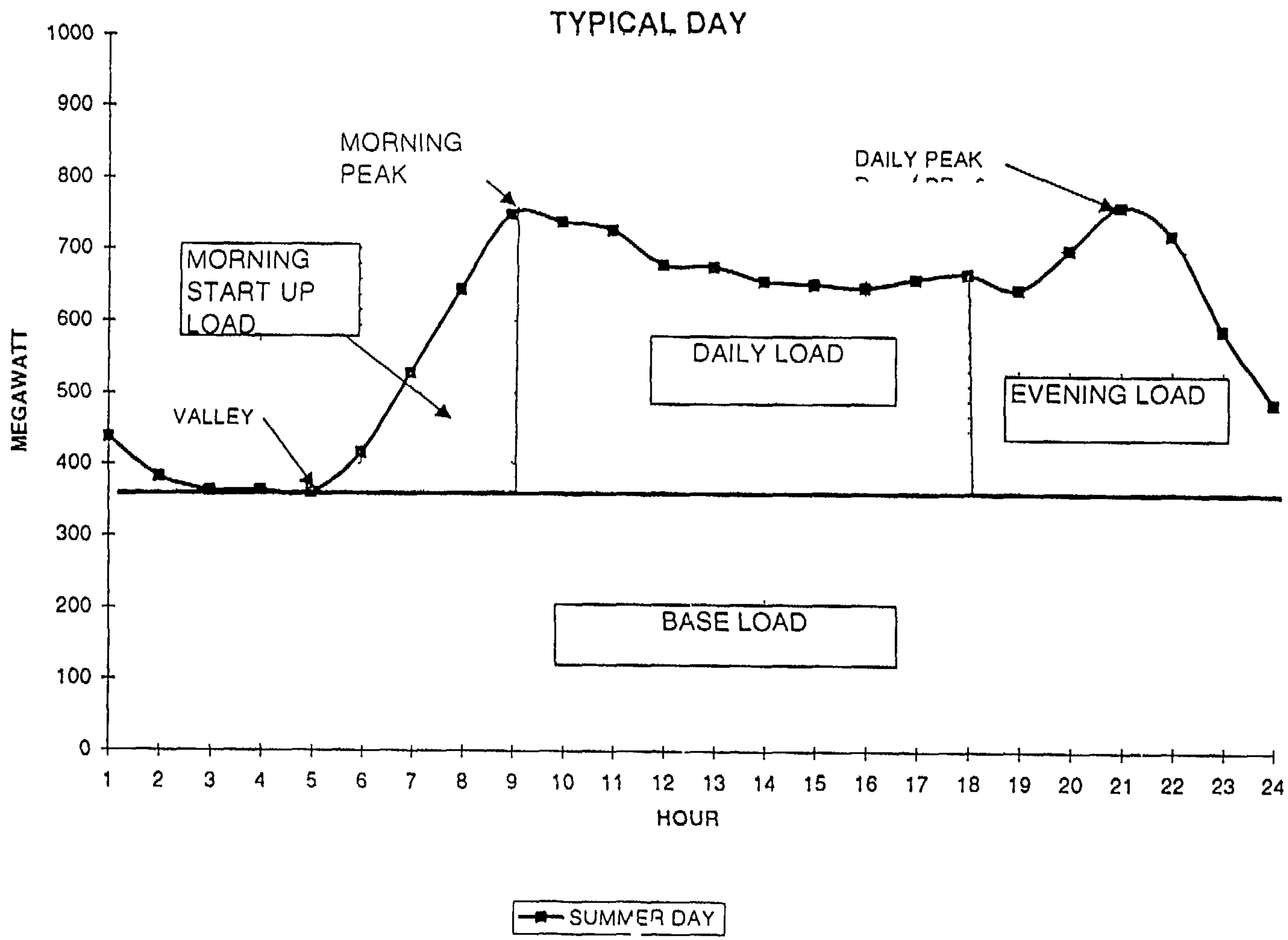

TYPICAL DAY
MEGAWATT
HOUR
SUMMER DAY
EARLY MORNING LOAD
VALLEY
MORNING START UP LOAD
MORNING PEAK
WORKING DAY
DAILY PEAK
EVENING LOAD

Applying typical hourly activities (*Figure 3 7*), we can begin to understand what activities contribute to the load For instance, it is easy to see the daily "start-up" load as people wake in the morning and start to get ready for work or the day's normal activities This is characterized by an increase in electrical consumption between the hours of 5 and 9 am The hours of 9 to 6 pm typically represent the working day It is interesting to observe that these hours are characterized by an average lower electrical load than the morning peak load This morning peak could be caused by start-up demand for industrial customers The hours from 6 pm to midnight are typically comprised of residential loads The load from midnight decreases substantially until about 5 am, when the pattern is repeated

Another aspect of the data can be illustrated by focusing on the daily low point or valley of the daily load curve Amounts below the valley level represent loads that are present 24 hours a day, while the loads above this point represent the electrical end-uses that are influenced by the time of the day, by the residential, commercial, or industrial users We can draw a horizontal line across the graph (at this valley level) to divide the load curve into a user-controlled area and a sunken load, as shown in *Figure 3 8* The sunken load is contributed by end-use activities that are constant throughout the day, such as a combination of municipal energy uses (street lighting, water pumping, electric transportation) Domestic water and sewage pumps operate continuously and have been estimated at about 40 MW (calculated from energy data based on personal communication) Some of this sunken load could also be residential loads such as refrigerators, since they cycle on and off to maintain temperature *Figure 3 9* shows the user load divided into daily activities, along with the base load, which allows a more detailed review of the load curve

Figure 3 8


TYPICAL DAY
DAILY PEAK
MORNING PEAK
VALLEY
USER CONTROLLED LOAD
BASE LOAD
MEGAWATT
0
100
200
300
400
500
600
700
800
900
1000
HOUR
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
SUMMER DAY



TYPICAL DAY
MEGAWATT
HOUR
1000
900
800
700
600
500
400
300
200
100
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
MORNING PEAK
DAILY PEAK
MORNING START UP LOAD
DAILY LOAD
EVENING LOAD
VALLEY
BASE LOAD
SUMMER DAY

Figure 3 9

An analysis of the summer load curve indicates that the sunken load averages a little over 300 MW Although their end-use efficiencies can be improved, it is fairly reasonable to assume that the sunken load cannot be reduced by any simple cost-effective changes by the end-user Until a detailed break-up and explanation of this sunken load can be developed, the end uses causing this sunken load should not be the focus of end-user efficiency improvements to be implemented through DSM programs

During the summer, the morning electrical load increases between 5 and 9 am These increases would be attributed mainly to residential increases plus some industrial start-up loads Another contributor could be the additional electricity required for enhanced municipal water pumping (building water pumps regulated by the water utility and operated from 8 to 10 AM in the mornings) The residential load would be comprised of lighting, television and radio, electric cooking, and general preparation activities prior to individuals going to work

It is interesting to note that following this period, the electrical load decreases by around 100 MW until late afternoon, when a slight increase begins During these hours, the load has shifted mainly from a residential load to a commercial/industrial load However, this decrease in electrical load is not typical of industrialized nations The uncertainties within the Armenian economy contribute greatly to this phenomenon What this means is that the daily combined industrial/municipal/commercial loads are less than the early morning residential load

The evening hours indicate that the electrical load is quite stable until around 8 pm, when it increases dramatically This is undoubtedly due to the summer weather, when there is more sunlight and the pleasant weather encourages outdoor activities At nightfall, the electrical load increases as individuals go indoors and turn on televisions, radios, and lights During the summer, the duration of this evening peak is also relatively short, indicating a two- to three-hour period of intense usage

The winter curve resembles the summer curve, however the morning load does not begin to increase until later in the morning, indicating that individuals sleep later because of the increased darkness and colder temperatures The evening peak begins much earlier in the evening, around 5 pm Also, the peak has a much longer duration, lasting five hours with a slightly lower demand for an additional two hours Overall the evening peak duration is roughly seven hours

The magnitude of the increase is greater in the winter than in the summer, approximately 400 MW to 300 MW, respectively This increase is probably due to the use of electrical space heating throughout the entire society

Summary of Load Characteristics

We have assumed a typical day to illustrate these basic points of the load curve However, there are basic differences between the daily loads For instance, the base load (the load below the daily valley) tends to vary throughout the year Depending on the month, the whole load curve shifts up or down *Figures 3 1* through *3 4* show that the data tends to be split into summer and winter periods of the year In general, the data tends to be seasonally sensitive

Reducing the winter evening peak should be of major concern to the utility In addition, the difference between the summer and winter base load (minimum consumption) is of extreme interest For the summer period, the base electrical demand is about 315 MW, while in the winter this value is approximately 850 MW Determining what contributes to this winter base load is important in determining if it is possible to reduce the total load

Another extremely interesting fact is that there is very little difference in the mid-week to weekend load curves, as shown in *Figure 3 5* The load curves are essentially the same, especially in the summer months While there is generally good correlation for the summer months, the winter months are more affected by weather conditions, and the daily curves tend to differ more (Since there are very few residential air conditioners in Armenia, summer electrical energy usage does not tend to fluctuate with weather conditions)

The similarity of electrical demand data between weekdays and Sunday means that there is essentially little sectoral impact on electrical load from day to day Typically, the load curve should show greater variation because of industry, which generally operates during the week but not on weekends The similarity of the load data for weekday and weekend day however means that, in Armenia, either industry operates at the same level every day or there is little industry to influence the load curve The latter is more likely the case, because the Armenian industry sector is currently in a very bad shape One other possible explanation for this phenomenon could be that the magnitude of the weekday industrial plus commercial load is essentially the same as the weekend residential load, but this coincidence seems unlikely [15] Since there is very little end-use data which identifies what each sector consumes, the sectoral end-use consumption of electricity needs further investigation

Sectoral End-Use Estimates

The lack of electrical meters, and/or their unreliability, as well as the high "commercial losses" in Armenia means that much of the data that is normally used to analyze electrical loads is not available The data that is available is not to the level of detail that would normally be employed to allow a complete analysis For instance, it is not known exactly how much electricity is used by the various sectors However, estimates based on figures provided in a recent document is shown in Table 3 1

[15] In this case, the electrical end-use might change from day to day, but the overall quantity does not change

Table 3 1
Sectoral Breakdown of Electricity Demand

Sector	Percent of Total Annual Electrical Load[16]
Residential	46%
Non-industrial	13%
Public Sector	12%
Industrial	9%
Drinking water	5%
Commercial	5%
Urban Transport	4%
Agriculture	3%
Rail Transport	2%
Construction	1%

Source Ministry of Energy (1997)

[16] Due to rounding off, the total is 101% rather than 100%

Before effective DSM programs can be developed, it is imperative that the specific end-uses of electricity, including how and when it is used, are fully understood It would seem logical that the best opportunity to save energy would be where the most energy is used A review of the above information would indicate that the residential sector should certainly be a priority, as it dominates the consumption of electrical energy After that, the next highest users are non-industrial, public sector, and industrial Following is a brief discussion of what is known or can be assumed regarding electricity demand in the residential, industrial, and commercial sectors

D Industrial Demand

Referring to *Figure 3 9*, it is fairly safe to say that the industrial/commercial load does not exceed 300-350 MW (the difference between the daily load curve and the sunken load from about 9 am to 6 pm) for the typical day shown For purposes of this analysis, we will use a value of 325 MW as an average for the user controlled load between the hours of 9 am and 6 pm

A TACIS report on Armenian industry (TACIS, November 1996) stated that "the electric consumption of industry in 1994 is around 1,000,000 MWh according to Armenergo, and 665,000 MWh according to the State Statistical Department " Assuming that Armenian industry has not slipped since 1994, industrial electrical consumption should remain at the levels stated or be higher Generation data for 1997 indicates that there was a total of 5,934,682 MWh produced, with transmission/distribution losses of approximately 21% This means that total consumption for 1997 was about 4,500,000 MWh Using the average of the 1994 industrial values shown above (average of 1,000,000 MWh and 665,000 MWh is 825,000 MWh), industrial consumption averages about 14 or 15 percent of total electrical production, or about 18 5% of the total customer consumption

On the basis of a standard 5-day work week and fifty-two weeks a year, there are 260 work days in a year The normal work day is assumed to be eight hours long Using these values and the estimate above for industrial consumption, the average industrial electrical consumption during the working hours is 400 MW In reviewing the load curves (see *Figure 3 8*), none of the curves seem to indicate a load of this magnitude between normal working hours (9 am - 6 pm) in relationship to the base load (usually occurring around 5 am) In fact, the load difference between the standard working hours and the daily base is only in the range of 300 to 350 MW This load is certainly comprised of sector loads, including industrial, commercial, and some residential From this analysis, it can be concluded that the 1994 estimates of industrial consumption do not agree with the 1997 hourly generation data, and these previous estimates appear to overestimate the consumption by industrial customers This would mean that the level of industrial energy use has fallen dramatically since 1994 [17]

[17] For instance, one of the major industrial consumers near Yerevan with a rated capacity of 80 MW was generally consuming a maximum of only 30 MW during the first quarter of 1998 (personal communication)

This is also consistent with the Government estimates which indicate that, following the collapse of regional trade, payment agreements, and severely shrinking markets for major industrial products in the Former Soviet Union countries, Armenia's industry sector output has decreased by over 60% (Ministry of Energy, August 1997)

Even if the industry operated six rather than five days a week, the hourly load would be over 333 MW This is still larger than the typical daily data indicates The issue for the demand analysis, then, is to improve the estimate of industrial consumption

From the load analysis, we know that the period from 9 am to 6 pm has industrial, commercial, and residential load components and that the hourly average is about 3255 MW However, we don't know what quantity each component consumes Summing the electrical demand between the hours of 9 am to 6 pm for the entire year yields 1,915,315 MWh If the base of approximately 350 MW from 9 am to 6 pm is subtracted from this value, this load becomes 765,565 MWh (1,915,315 MWh minus 365 days times 9 hours times 350 MW) Again, this is for seven days a week and is the total of all user-controlled loads (Table 3 2) Percentage values for the portion of the load that would be residential and commercial can be estimated to determine what the industrial load would be

Table 3 2
Estimates of Annual Electricity Consumption (7-day week)

	Estimated Percentage	Annual Consumption
Residential	10%	76 557 MWh
Commercial	20%	153 113 MWh
Industrial	70%	535,895 MWh
Total	100%	765 565 MWh

Assuming that industry accounts for 70% of the electrical load between the hours of 9 am and 6 pm, it is then obvious, from the 1997 data, that the industrial load cannot account for more that 535,895 MWh Again, this estimate is calculated for seven days a week If Sunday data is removed from this analysis, then the total consumption between the hours of 9 am and 6 pm is 659,223 MWh (765,565 MWh minus 106,342 MWh) Applying the same percentages as above yields the following results (Table 3 3)

Table 3 3
Estimates of Annual Electricity Consumption (Sundays not included)

Residential	10%	65 922 MWh
Commercial	20%	131 845 MWh
Industrial	70%	461,456 MWh
Total	100%	659 223 MWh

Therefore, the industrial electrical consumption for six days a week from 9 am to 6 pm (assuming an industrial ratio of 70%) is 461,456 MWh, and for seven days a week, the value is 535,895 MWh Since the Armenian economy is just beginning to rebound after the breakup of the former Soviet Union, it is fairly safe to assume that few industries operate more than the standard one shift per day Therefore, the majority of the industrial electrical load would occur between the hours of 9 am and 6 pm These numbers are substantially below the estimated 1994 values cited earlier by Armenergo and the State Statistical Department

The above values are based on the assumption that the industrial load is seventy percent of the total user controlled load during the hours of 9 am and 6 pm This is only a very rough estimate, and in fact, this percentage could be much less While the residential load during this period is probably not too high, the commercial load could be higher than the twenty percent value shown As the commercial value increases, the industrial value would need to be lowered If the industrial value were 50%, the industrial load would be between 329,612 MWh for a six-day week and 382,783 MWh for a seven-day week Since there is very little accurate metering, it is difficult to be exact in this value However, it is probably safe to say that between the hours of 9 am and 6 pm, the Monday through Saturday industrial load is between 329,612 MWh and 461,456 MWh

Representatives of the Energy Commission have stated that in 1997, the industrial load accounted for about ten percent of the total load Using this information, the total annual industrial consumption would be 468,840 MWh (ten percent of the total annual load of 4,688399 MWh) Assuming an industrial work schedule of six days a week, the hourly value is then 167 MW per hour (468,840 MWh divided by 52 weeks by 6 days per week by 9 hours per day) This value increases to 200 MW per hour if the work week averages five rather than six days per week In the previous analysis, user-controlled load between the hours of 9 am and 6 pm averaged 275 MW Using seventy percent of this figure as the estimated industrial load, the industrial load is 193 MW This value compares favorably with the values of 167 and 200 MW previously calculated Therefore, the assumption of seventy percent of the load during the day being industrial appears to be reasonable

E Residential Demand

The user-controlled load has been previously defined as the difference between the total consumption curve minus the base load of 350 MW each hour The data provided indicates that the annual demand is 4,688,399 MWh Subtracting 3,066,000 MWh (350 MW for 365 days at 24 hours per day) yields a user controlled load of 1,622,399 MWh We have already shown that the consumption between the hours of 9 am and 6 pm is 765,565 MWh, of which an estimated 10%, or 76,557 MWh, was residential The evening and morning start-up load then equals the difference between the user-controlled load of 1,622,399 MWh and 765,565 MWh, or 856,834 MWh

The evening and morning start-up periods are dominated by the residential loads While there would be some commercial loads in the evening (restaurants, theaters, and other entertainment), the commercial morning load would be very small Therefore, the residential load is assumed at 85% percent for the evening and morning loads, with the remaining 15% being commercial and miscellaneous loads

Based on these assumptions, the residential load would be

Evening and morning start-up period	728,309 MW
Daily load (9 am to 6 pm)	76,557 MW
Total residential load	804,866 MW

F Commercial Demand

Since industrial customers are believed to consume 10% of the electricity and residential customers consume 50%, this means that 40% is unaccounted for Commercial customers and miscellaneous users have to account for this forty percent, but it is difficult to look at the load curves and see any discernible pattern that would be obviously attributed to commercial customers Nevertheless, the commercial load is assumed to occur during the standard period from 9 am to 6 pm

4 ELECTRICAL TARIFF ANALYSIS

One of the most fundamental aspects of any business is that the revenues must be greater than the total expenses For Armenia's electrical industry the comparison of income and expenses is difficult to make because of the complexity of the generation of electricity This is generally true for most utilities, as they tend to have multiple generation sources However, the costs of generation and maintaining the electrical system have been established by the Energy Regulatory Commission[18] of the Republic of Armenia and are shown in *Table 4 1* below

Table 4 1
Generating Costs by Plant

Complex of the Vorotan Hydro power plants	1 37 drams[19]/kWh
Cascade of Sevan-Hrazdan hydro power plants	4 21 drams/kWh
Privatized small hydro power plants	13 00 drams/kWh
Hrazdan thermal power plant	15 48 drams/kWh
Yerevan thermal power plant	16 26 drams/kWh
Armenian (Medzamor) nuclear power plant	12 37 drams/kWh

Source Energy Regulatory Commission (1997)

The suppliers[20] sell power to one national carrier Armenergo, that is responsible for operating the transmission (110 / 220 kV) network in Armenia's six regions, and for dispatch,[21] imports and exports[1] Distribution of power to end-users (at 6/10 kV) is done by eleven distribution enterprises, one in each of Armenia's eleven provinces (*marz*), including one in the capital city Yerevan (Yerevan Distribution Company)[22] Yerevan and several smaller cities are mainly supplied by underground system, while remainder of the country by overhead distribution system Metering on the distribution system is virtually non-existent at present, resulting in commercial losses[23]

[18] Resolution No 6 dated August 1 1997 (Energy Regulatory Commission, 1997)

[19] At the time of writing this report 1 US$ = 500 drams

[20] All supplier enterprises except Armenia (Medzamor) nuclear power station, are going to be privatized The seven small hydropower stations were privatized in 1997

[21] Currently the dispatch function is merely an allocation of existing supply and not economic dispatch Operation of the transmission network as a radial system has also resulted in decreased system stability

[22] In July of 1998 these eleven distribution companies were further consolidated into only four regional (including one in Yerevan) distribution companies (personal communication)

[23] A proposed World Bank/OECF (Japan) program aims to provide multi-tariff meters on the distribution system nodes (Ministry of Energy, August 1997)

The costs shown in Table 4 1 represent average costs for operating each supply facility However, when the nuclear plant is operated during a summer night, it operates at partial load (at approximately 50% of its capacity) Estimates show that operating this plant at partial load increases its operational costs 3 5 times the full load operating costs If the nuclear plant is to continue in operation, it should be loaded closer to its rated capacity, which will help to keep both the nuclear plant operating costs and power system average costs low [24]

The Energy Act of 1997 established an independent Energy Regulatory Commission, which sets tariffs for all sectors, issues production licenses, and is responsible for creating equal conditions for all entities The Energy Regulatory Law, adopted in June 1997, defines the principles to be applied in setting energy prices and tariffs The pricing reform aims to gradually increase the tariffs to full recovery The electrical tariffs that different types of customers currently pay are shown in Table 4 2

Table 4 2
Electrical Tariffs (1997-98)

Sales to distribution networks (average)	15 34	drams/kWh
Sales to 35 kV and higher voltage customers	16	drams/kWh
Sales to direct customers of 6-10 kV	20	drams kWh
Sales to 0 4 kV customers		
Residential up to 100 kWh/month	15	drams/kWh
Residential 100-250 kWh/month	22	drams/kWh
Residential greater than 250 kWh/month and all other 0 4 kV customers	25	drams/kWh
Sales btn 11pm-7am to high voltage customers on TOU	12	drams/kWh

[24] As discussed earlier there are social and political efforts to close this plant due to impending risks arising because of its location on or near an earthquake fault zone In 1989 Medzamor nuclear power plant was shut down owing to the fears of seismic damage caused to the power station by the 1988 earthquake One of its 440 MW units (Unit 2) resumed operation in late 1995 to overcome the acute electricity crisis and to help reduce over-reliance on hydropower that was (and still is) leading to serious lowering of Lake Sevan (Ministry of Energy, August 1997) Armenia's government currently also has plans to reactivate Medzamor s Unit 1 (USEIA, 1996), while it also plans on the other hand, to close down the entire nuclear facility by 2005

Features of Tariffs and Costs

1 Yerevan power plant has costs that exceed 16 drams/kWh Yet, some of the tariffs are below 16 drams/kWh Without knowing how much contribution is made by the Yerevan power plant to the total supply, it is difficult to know if the tariffs are adequate to cover the costs
2 The nuclear plant costs are shown as 12 37 drams However, at a summer night this unit is operated at partial load (approximately 180 MW) Ministry of Energy and Fuels staff have indicated that the costs of operating this unit at partial load at 3 5 times the full load cost This would mean that the cost of operating this unit at full load would be about 5 5 drams/kWh
3 Residential rates are substantially more expensive than the other rates, except for the lowest level of consumption which is priced at 15 drams/kWh [25] This rate is potentially below the cost of supplying electricity as shown in Table 4 2 Residential customers falling into the other two rate categories contribute the most towards recovering the supply costs The breakdown of how many residential customers fall into which tariff category is unknown However, many residential customers are very conscious of electrical use, and try to minimize it It is possible that the majority of the customers are in the lowest tariff category, which may be below the cost of supplying electricity
4 The rate charged to distribution companies is also below the cost of supplying electricity
5 The World Bank has been supporting the idea of a 20 percent increase in electrical tariffs for over a year
6 The tariffs do not include a demand charge and rely solely on energy costs Demand charges are normal, especially for industrial customers, and this type of tariff should be considered for Armenia

An in-depth review of the electrical supply costs and tariffs is beyond the scope of this project Such an analysis is the focus of other USAID-funded efforts, including the work that one USAID contractor is doing in establishing and enhancing the capabilities of the Energy Regulatory Commission However, it is easy to see that from a purely technical viewpoint the tariffs need to be raised The question is whether the 20 percent increase suggested by the World Bank is adequate However, raising the tariffs would require a thorough analysis of what the tariffs should be as well as what the consumers can afford to pay Raising the tariffs may result in an increase in non-payments, and increased thefts of electricity[26] It is also a politically and socially unpopular move [27]

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[25] Due to cross-subsidies

[26] Technical and Economic Analyses of Measures for Expenditure Stabilization and Tariff Regulation in the Power Sector of the Republic of Armenia (Lahmeyer July 1998)

[27] In 1997 average tariff was raised by 40% from 3 3 cents per kWh to 4 6 cents per kWh (USEIA 1996) with lower prices for the low-income customers Because tariffs are a heavy burden to most Armenian families, there is a growing public discontent (RFE/RL 1998) as the cost of production is less than half this figure (average generation cost is about 2 3 cents per kWh according to Energy Regulatory Commission 1998) but the high cost of supply is a result of disproportionately large transmission and distribution (T&D) losses In fact the supply costs are so high (6 cents per kWh) that the sector has to rely on government subsidies

5 ENERGY EFFICIENCY INFRASTRUCTURE

In Armenia, there are many institutions and organizations that could play key roles in implementing energy efficiency projects and programs These include the government, energy sector entities, educational institutions, donor agencies, and the private sector At this time, there is no specific organization responsible for energy efficiency development and implementation, although there is an Energy Efficiency Law being considered by the Parliament The following paragraphs provide information on some of the organizations that are associated with the energy efficiency activities

Armenian Government

The Ministry of Energy (MEF) has the most significant influence over the development and implementation of energy efficiency programs The MEF is responsible for managing the overall energy sector and for developing long-term strategies Within the MEF there are three key organizations the Department of Research and Development, the Energy Institute, and the Energy Strategy Center In addition to the MEF, there are other specific governmental organizations charged with energy sector-related issues The following are descriptions of these government organizations

Energy Regulatory Commission

Established by the Energy Act of 1997, the Energy Regulatory Commission is responsible for setting tariffs, issuing production licenses, and for creating equal conditions for all entities

Ministry of Environment

Ministry of Environment regulates and monitors emissions, and monitors the water flow of Lake Sevan (associated with hydro power plants), which impacts hydroelectric production capacity

Ministry of Industry and Trade

The Ministry of Industry and Trade is currently involved in restructuring various industries to make them ready for privatization Key industries are currently being surveyed, and part of the survey is also to evaluate the energy usage [28]

Ministry of Economy and Finance

This ministry assists in developing and monitoring the expenditures of the national budget, including making assessments of any credits that require sovereign guarantees

Parliament

The Parliament is responsible for developing and approving legislation, such as the Energy Act of 1997 Under current parliamentary discussion is an Energy Efficiency Law A draft of the law is included as Appendix - IV The draft law specifies that its purpose is to define the legal framework for implementation of state policy in the energy efficiency sphere However, the draft

[28] Results of this Ministry of Industry and Trade survey will be available in October 1998 (personal communication)

does not specify the state agencies responsible for developing and implementing energy efficiency strategies, nor does it address the funding of energy efficiency mandates

Municipalities and Other Local Government Entities
These entities control a substantial part of the market for energy efficiency projects Publicly provided services such as district heating systems, street lighting, and water/sewer systems are, in part or whole, the responsibility of municipalities In addition, these entities are responsible for the many public buildings such as schools and office buildings

Ministries of Education, Health, and Social Services
These ministries are in charge of many buildings serving public needs such as universities and schools, hospitals, orphanages and elderly homes, and refugee centers

Electric Energy Sector Entities

Energy Generation Companies
Power plants such as the Armenian Nuclear Power Plant (Medzamor) have an interest in running at peak capacity in order to increase its efficiency and decrease its generation costs

Energy Distribution Companies

As distribution companies are privatized, they will rely more on providing energy efficiency services in order to attract or keep customers, and making their own operations more efficient

Educational Institutions

Technical Universities
These have the capability of providing support for and coordination with other energy sector players Potential activities include research and development of energy-efficient appliances, information dissemination through conferences and workshops, energy auditing training, and energy efficiency design training

Private Sector

Energy Service Companies
The Energy Service Companies (ESCOs) are entities that provide services related to implementation of energy efficiency projects and marketing for energy efficiency activities Some ESCOs have emerged in Armenia but it is still a fledgling industry In doing energy efficiency implementation in certain sectors, such as the commercial and buildings sector, ESCOs will have an enormous potential and role to play in the future

Equipment Manufacturers
Some manufacturers, like the existing lighting equipment manufacturer Luis Lamp Plant, is a potential manufacturer of energy-efficient lighting Foreign companies, like General Electric, are also interested in tapping this potentially large market for energy efficient lamps Other local

industries are also potential manufacturers of energy efficiency appliances, boilers, air conditioners, motors, meters, etc

Non-Governmental Organizations

These organizations can play influential roles in research, policy development, training, creating public and government awareness for energy efficiency and in information dissemination

Association of Energy Engineers

This membership organization recently organized and hosted an International Energy Conference in Yerevan which was attended by some 200 local energy experts It is presently developing strategies for the district heating system and is active in developing renewable energy sources

ECO-TEAM

This group is involved with energy-related environmental issues

Multinational Development Banks and Donor Agencies

Institutions like the World Bank, European bank for Reconstruction and Development, United Nations, US Agency for International Development and TACIS are playing critical roles in assisting Armenia's transition from a centrally planned economy [29] Most of the foreign investment coming into Armenia is channeled through the Government

[29] The reforms that have led to the revival of Armenia s electricity sector thus far, have partly been supported by foreign (primarily Western) aid

6 DSM PROGRAM DEVELOPMENT AND STRATEGY ANALYSIS

A Significance of the Residential Sector

As discussed in previous sections, the residential sector currently contributes the most to electricity demand (see *Table 6 1*) Because of the limited availability of district heating and natural gas, residential customers have started to rely more heavily on electricity for space heating, water heating and cooking This results in a higher share for the residential sector than would normally be the case

Table 6 1
Sectoral Electricity Consumption Characteristics

End-Use Category (Units)	***Year***	
	1996	**1997**
Total Consumption (GWh)	4518	4528
Agriculture (%)	6 7	4 8
Transport (%)	3 8	3 2
Industrial (%)	18 0	14 5
Residential (%)	45 1	46 8
Others (%)	23 6	27 3
Exports (%)	2 8	3 4

Note "Others" includes water and sewage pumping systems, street lighting and electricity usage in the commercial sector, government buildings, schools and hospitals etc

Source Ministry of Energy (August 1997)

Table 6 2 shows 1997 tariffs for different categories of residential customers

Table 6 2
Armenia Residential Energy Tariffs

Type of Customer	**Electricity Tariff in 1997**
Residential Customers on 400	
High Consumption (Higher than 250 kWh per month)	25 Drams per kWh
Medium Consumption (100-250 kWh per month)	22 Drams per kWh
Low Consumption (Lower than 100 kWh per month)	15 Drams per kWh
Average (weighted by total consumption)	21 Drams per kWh

Note US$1 00 equals 500 Drams (April 1998)

Source Energy Regulatory Commission (1997)

It is clear from *Table 6 1* that the residential sector, as a single-consumer category, currently has, and will continue to have, a major role to play in dictating electricity consumption amounts and patterns (See Chapter 3 for a further discussion of load profile) In this context, the significant questions to be answered are what end-use targets within residential sector needs immediate attention and how Day/Night tariff based DSM programs can be implemented in this sector The following sections are an attempt to understand the end-uses, and determine which of them would be the best candidate for the differential tariff system

A recent estimate of the end-use load profile done for Armenia's urban and rural areas, through an analysis of household electricity needs, appliance penetration rates and associated coincidence factors, is presented in *Table 6 3* The average consumption in urban areas is remarkably higher (almost double) than that of rural consumers Projected forecasts also indicate that Yerevan's electricity consumption growth rates will be very high as compared to Armenia's other ten "distribution" regions over the next 8-10 years (Ministry of Energy, August 1997) Hence, potential residential DSM programs in the short-term should focus on the Yerevan region

Table 6 3
Residential Electrical End-Use Load Profile in Armenia

End-Use Category	Urban Area (Yerevan)				Rural Area			
	Load (kW)	Pene-tration (%)	Opera tion (hours)	Average Consump (kWh/day)	Load (kW)	Pene tration (%)	Opera-tion (hours)	Average Consum (kWh/day)
Space Heat	2 80	70	2 0	3 92	1 20	70	1 0	0 84
Water Heat	2 00	60	1 5	1 80	1 00	50	1 5	0 75
Cooking	1 25	70	1 5	1 31	1 25	40	1 0	0 50
Lighting	1 00	100	3 0	3 00	1 00	100	3 0	3 00

Note Operation hours are coincident peak hours that is hours of operation coinciding with the power system peaks

Source Ministry of Energy (August 1997)

From Table 6 3, it can be inferred that the focus of load management (load shifting) should be on space heating, water heating, cooking and lighting end-uses However, in order to develop more reliable and useful electricity distribution and end-use load data, and to estimate the customer response to a possible residential Day/Night tariff system, an electricity end-use saturation survey of Yerevan's residential customers (a sample of 1,000 apartment units) was carried out under this project [30] The results of this survey are presented in Appendix-I [31] However, some of the important

[30] Reliable energy end-use information is generally not available in Armenia (Ministry of Energy, August 1997)

[31] The complete results and analysis of this residential end-use survey will also be published as a separate report

results, that relates to the formulation of Day/Night tariffs and target end-use technologies, are also included in the following sections

Residential End-Use Survey

The comparison of electricity uses in the winter and summer obtained through the surveys of 1000 dwellings are summarized in *Table 6 4*

Table 6 4
Weighted Average Electricity Use by Appliance Type

	Winter	**Summer**
Space Heating	42%	Not Applicable = Seasonal Saving
Electric Stove	13%	12%
Lighting	12%	6%
Hot Water Heating	11%	8%
Refrigeration	10%	17%
TV	7%	6%
Ironing	2%	2%
Other	3%	3%

Lighting, hot water heating, and refrigeration are the only appliances that have substantial differences between summer and winter use (subtracting out winter space-heating requirements) The differences in lighting and refrigeration can be easily explained by seasonal variation - longer daylight hours in the summer, warmer temperatures (in winter, some items are stored on outside balconies, rather than in refrigerators) The difference in hot water heating in the summer may be due to lower requirements for clothes washing, and to fewer hot water requirements for bathing

Table 6 5 summarizes the appliance use data from the surveys for those appliances which have the highest electricity consumption

Table 6 5
Appliance Electricity Usage Characteristics

Type of Appliance[1]	Typical Rated Wattage (kW)[2]	Average Hours of Use Per Day	Typical kWh Consumption Per Day	Penetration Rate
Lighting	0 28	5	1 4	100%
Space Heating[3]	2 8	3	8 4	60%
Hot Water Heat	1 0	1	1 0	94%
Television	0 10	6	0 6	96%
Refrigerator[4]	0 15	24	3 6	88%
Electric Stove	1 0	2	2 0	85%

Notes
1 Only lighting has more than one appliance per apartment with varying sizes, e g , 40watts and 60 watts All appliances, other than lighting, are one per apartment where their usage is reported
2 Penetration rate is defined as the percentage of residents which own a given appliance
3 Space heating and air conditioner use are seasonal
4 The compressor of the refrigerator cycles throughout the day depending upon the ambient temperature and the number of times the refrigerator is opened during the day The detailed estimate of the average number of hours per day was beyond the scope of the survey

Survey respondents were also asked which appliances they would replace if they had any extra money The most common responses (in order) were TV (30%), refrigerator (20%), washing machine (20%) and other (vacuum cleaner, audio center, etc - total 30%) Approximately 20% of residents did not reply to this question, since they did not anticipate having any extra money for the purchase of new appliances These replacement expectations may have some impact on the selection of potential informational type DSM programs and appliance standards and labeling policies

In the survey, residents were asked if they would shift their use of electricity if given a preferential tariff, and what level of tariff reduction would induce them to shift Residents were given a choice of preferential tariff equal to 25, 50, and 75 percent of current tariffs In all categories, 75% - 85% of the residents said that they would consider shifting their electricity usage to night-time (2300 to 700 hours) if given a preferential tariff Their responses to the level of inducement necessary to influence such a shift is shown in *Table 6 6*

Table 6 6
Willingness to Shift Electricity Usage to Night-Time (2300-700 hours)
Based on Tariff Level (Percentage of Day-Time Tariff)

	25 Percent	50 Percent	75 Percent
Single-Family	18%	8%	74%
4-6 Story	45%	38%	17%
9-12 Story	36%	45%	20%
14-16 Story	45%	43%	12%

Residents were also asked which usages they would be willing to shift to non-peak times Most often mentioned were bathing, clothes washing, ironing, and cooking Bathing and clothes washing would affect the electricity used in water heating As seen in Section 5 of this Appendix, these are not the highest electricity usages as determined by the survey Together, they account for only 22% (summer) to 26% (winter) of residential electricity use Ironing only consumed 2% of electricity use Furthermore, not all of the usage can be shifted to non-peak hours The uses that have the highest electricity consumption, i e refrigeration and space heating, are the least amenable to shifting their time of use and should perhaps be the focus of energy conservation type DSM programs

The results of this survey of household electricity usage patterns provides information about the importance and nature of various end-uses and potential DSM strategies and programs

B Load Management Programs, Barriers and Strategies

Typically, load management (or changing the timing of electricity usage for end-uses) is achieved through tariff mechanisms (programs such as time-of-use, real-time, and curtailable or interruptible tariffs) or direct load control Load management programs do not require high investments, except for metering requirements For implementing load management-type DSM programs, the end-use has to be flexible or "elastic" (over time), which limits its application in many situations

In Armenia, load-shifting options (from day time to night time) meet the objective of being able to run Medzamor nuclear power plant and the Yerevan thermal power plant more efficiently Load-shifting type of DSM programs will have to be simple (two-part) due to metering costs They also have to rely primarily on behavioral change or changing the electricity end-use appliance or equipment usage patterns It should be noted here that a voluntary industrial TOU tariff system is already in place, and residential TOU tariffs are being considered [32] However, only 48 industrial consumers (mostly bread factories) are on this day/night tariff system and the impact on the load curve has been minimal thus far (personal communication) [33]

It was evident from the discussions with the Ministry of Energy and other Government agencies that load shifting-type DSM programs is of significance to utilities and policy makers This is primarily driven by the objective of increasing valley load levels which would result in higher generation efficiency and lower generation costs (this matter have been explained in the foregoing sections in detail), and increasing exports during peak (day-time) hours A TOU tariff (Day/Night tariff) is therefore an attractive option [34]

However, the former objective is so appealing to the officials that some proponents of this idea even suggested considering simple valley-filling DSM programs (as compared to load-shifting) The latter option could be incorporated into strategic load growth DSM strategies

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[32] As discussed earlier, these are day-night tariffs for the high voltage consumers with the low night tariff of 12 drams per kWh during 11pm to 7am

[33] No specific analysis has been done of the load shifting impacts that may have resulted from the voluntary Day/Night tariff However, the general opinion of persons consulted was that there has not been any specific load shifting that could be accounted for by the preferential night tariff This is partly due to the " free-rider" effect where the bread factories which would have operated at night in any case are taking advantage of the savings (and their electricity bill reduction) without really changing their electricity usage patterns

[34] It should be noted here that the lower generation cost advantages (and perhaps higher export earnings) resulting from the load-shifting (to night-time) by TOU tariff mechanism may be offset to some extent by lowered revenues collected from the rate-payers (due to lower night-time tariffs)

Residential Sector TOU Tariffs

Even though space heating is the largest end-use, except for the low income residential consumers however, space heating is not considered to be an end-use that is flexible enough to respond to differential pricing This was also indicated by survey respondents The tariff differential might influence low income customers (about a third of residential customers) to shift their space heating usage patterns, but metering constraints will prevent them from doing that Differential tariff meters, which cost about US$200 each with payback periods of more than 8 years, are beyond the means of the low-income customers Locally produced two-part meters are available at a cost of $90-$110 per unit which is also beyond the reach of most low income residential customers [35] Household customers in the high-income bracket may be able to afford the meters, however, energy cost shares for this category are relatively low and, therefore, their space heating usage price is likely to be inelastic, as the survey also suggests These problems make differential (Day/Night) tariff mechanism difficult to implement in reducing and/or shifting space heating loads for most of the residential customers

Nevertheless, Ministry of Energy officials estimate that 15%-20% load shift is possible by implementing TOU pricing strategies Time of use (Day/Night) tariff is potentially a viable option because over 75% responses in the survey also indicated that they would be willing to opt for the preferential tariff if this system is introduced This is also due to the fact that electricity costs have a substantial share (15%-25%) of their family incomes Usage pattern changes are possible for the end-uses of hot water (showers and clothes washing), ironing and cooking However, these end-uses' share is not very high, so the cost-effectiveness would not be as great as in the case of space heating end-use And, the program implementation costs (metering costs) associated with the differential tariff also in a barrier

According to some experts, if a TOU tariff is implemented in the residential sector, people will heat their water at night and use it in the morning (for showers and other uses) It was learnt that there is some Italian firm that produces equipment (super insulated heaters) that can store hot water very efficiently (estimated to be only one deg centigrade loss over 24 hours) If the appliance manufacturer (not yet contacted at the time of writing this report) could be encouraged to provide the heaters at a subsidized rate for the Day/Night Tariff program, this could be successfully implemented The incentive for the manufacturer would lie in making profits through higher sales of its product It was also suggested that load shifting will take place if the popular television (TV) programs are moved from peak hours (evening) to off-peak hours (late night) However, this approach could be problematic as it may disrupt social schedules Moreover, energy consumption for TV is not very high so the overall impact would be minimal

In case of residential customers, the meters could be financed by the generation cost savings (and perhaps additional export earnings due to excess electricity available during the peak hours) The average production cost is likely to come down by 3 cents per kWh even with 50 MW base-load filling (Lahmeyer, 1996)

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[35] YDC is considering a plan to introduce Day/Night tariff to low-income consumers and provide the meters to them (personal communication)

Alternatively, the differential (Day/Night) tariff strategy can be implemented in conjunction with an upcoming Ministry of Energy program through which a World Bank Loan is being negotiated [36] The Japanese grant of a World Bank loan will pay for the revenue (customer) metering that will provide single-phase meters at $110 per unit to 9 percent of Yerevan's residential sector by 2001, and 3-phase meters at $350 pr unit to all of Yerevan by 2005 The cost of the meters will be paid for by the commercial loss reduction and NOT by the consumers The WB part of the loan is for system metering [37] The current rationale is to pay for these meters through reductions in commercial losses, but additional benefits related to DSM and TOU tariffs from using these meters also exist The DSM program based on a TOU (Day/Night) tariff program could initially target the World Bank meter recipients In the long-term, financing of the TOU tariff meters could come from electricity production cost savings or through higher electricity export earnings

Industry Sector TOU

Load shifting usually requires some social or cultural adjustments, in that it can require industries to change the way that they operate and individuals to alter the way that they live Experience with the existing voluntary Day/Night tariffs available for industrial customers indicates very little impact Of the 48 industries that use the rate, most are bakeries that would normally operate during the off-peak hours anyway The voluntary rate has produced little or no shifting of electrical demand In fact, it has given those customers already operating at night a "free-ridership" by reducing their electricity bills

To successfully implement an industrial Day/Night tariff system, both off-peak and on-peak rates must be designed properly Industrial customers must sign up for the rate and agree to stay on it for a specified period of time This will reduce the number of customers who want to initially try the rate and then decide, after a brief period of time, that they want to go back to their previous rates Since investments in Differential tariff meters for customers enrolling for this rate have to be made , they need to be assured that they will not lose money by purchasing meters that are not used The TOU rates are designed so that the off-peak rate is attractive to customers, substantially lower than the standard rate (25% lower is a typical value) It should be attractive enough to industrial consumers to entice them to switch their operations to the night At the same time, the on-peak rates should be higher than the standard electrical rate This would serve as an

[36] This program includes metering management improvement, financial system improvement measures, and preventing further accumulation of debt The current accrued debt is 45 billion Dr, which would be paid for by (1) State budget (8 5 billion Dr) for essential supplies like drinking water budgetary organizations energy use etc , and (2) increased tariffs (8 5 billion Dr) plus 8 5 million Dr in inflation and exchange rates, for a total tariff increase of 16 billion Dr in 1998 This will result in an average tariff increase from 21 Drams per kWh to 25 5 Drams per kWh (personal communication) To offset this increase in tariff, cost minimization measures need to be identified that, among other measures could include shifting loads by means of a TOU tariff

[37] The Ministry has also requested US$50 million from US Agency for International Development, including US$4 5 million for system metering and US$10 5 million for revenue (customer) metering for residential single-phase meters to cover 45 percent of Yerevan (personal communication)

disincentive for the customer to switch back and operate during the day In addition to the possibility of financing the meters through increased generation costs savings (or export earnings), the implementation of this program could also be done through Energy Service Companies (ESCOs), wherein the ESCOs could provide and install the 3-phase meters at the industrial sites and have a one- or two-year contract of shared / guaranteed savings with the client

From a purely technical viewpoint, the Day/Night tariff should not be available to consumers who would normally operate at night anyway The purpose of the rate is to have customers switch to night operations in order to reduce the on-peak loads Customers who operate at night and are allowed to participate in the TOU rate are "free riders," taking advantage of the lower cost rates but not benefitting the utility by shifting any load

C Energy Conservation DSM Programs and Strategies

Energy conservation-type DSM programs (that reduce the amount of electricity for end-uses through efficiency improvements) include energy audits and information, incentives and loans, direct installation, and equipment supplier/vendor programs Energy conservation DSM programs almost always require monetary investments, which are paid back in time through savings The investments can be made by the utility or the customer or a third party like an ESCO, and the programs create a market for efficient appliances and equipment ("market pull"), which leads to market transformation That is, in the long run, the end-use equipment market is gradually transformed to more efficient stock due to this "market pull " As a result of market transformation, the "market push" (by efficiency equipment manufacturers and vendors), mechanism replaces "market pull" thereby making energy conservation a sustainable effort

Table 6 7 lists a broad array of appliances and equipment that are generally targeted through different energy conservation type DSM programs in the United States The efficiency improvements are implemented through programs which ranges from incentives to direct installation

Table 6 7
Energy End-Use Technologies for Efficiency Improvements through DSM Programs in the United States

Residential Sector	Lighting	Compact fluorescent lights
		Halogen lights
	Space Heating	Ground-source heat pumps
		Air-to-Air heat e changers
	Refrigeration	Efficient refrigerators
	Air Conditioning	Efficient air conditioners
	Building Envelope	Attic, wall and floor insulation
		Double and triple-paned windows
		Caulking and weatherstripping
	Water heating	Efficient electric water heaters
		Heat pump water heaters
Commercial Institutional	Lighting	Compact fluorescent lights
		32-watt and 36-watt fluorescent tubes
		Occupancy sensors and timers
		Dimming ballasts
	Space heating	Ground-source heat pumps
		Air-to-air heat e changers
	Refrigeration	Efficient refrigerators
		Doors covers on cases
	Water heating	Efficient electric water heaters
		Heat pump water heaters
	Air conditioning	Efficient air conditioners
		Occupancy sensors
	Building envelope	Attic, wall, and floor insulation
		Double and triple-paned windows
		Caulking and weatherstripping
	Controls	Energy management systems
Industrial	Lighting	High-pressure sodium lights
		Metal halide lights
		32-watt and 36-watt fluorescent tubes
	Motors and Motor Systems	Energy-efficient motors
		Multi-speed motors
		Ad ustable-speed drives
	Controls	Energy management systems

Armenia's energy end-use situation is however, different from the end-uses shown in Table 6 7 Again, in Armenia the focus of energy conservation program, at least in the short-run, will likely be on the residential sector The following paragraphs describes the various end-uses for which information was obtained through meetings, discussions and reports over the course of the project and areas which could be the target for design and implementation of energy efficiency improvement programs

Residential Sector End-Use Efficiency Improvements

Lighting

Lighting improvements are estimated to have a savings potential in the range of about 100 MW (Lahmeyer, 1996) Costs of saved energy for lighting improvements are also very low For instance, replacing a 100 watt lamp with a 18 watt compact fluorescent lamp (CFL) would save energy at 1 4 cents per kWh, considerably lower than what residential customers pay for electricity supply (Lahmeyer, 1996) In this case, however, investments would be required to provide incentives or rebates to customers to enable them to implement the measure One of the strategies could be to work with the local lamp manufacturer/vendor (vendor type DSM programs) to facilitate the development, manufacture, and availability of efficient lighting products like CFLs (market push activity) This should be both for fluorescent lamps and CFLs and possibly for motion-sensitive lights (especially for office buildings)

Water Heating

Electric water heater measures (including replacement with efficient water heaters, installing heater jackets, etc) could be viable options for a energy conservation DSM strategy However, implementing this measure would require initial investments, which could be provided through incentives and loans For a water heating end-use (for instance in 14-story buildings), YDC is very interested in a solar water heaters program [38]

Refrigerators and Televisions

Table 6 4 of the survey results suggests that refrigerators are a major-end use, particularly during summer Also, the survey suggested that among the appliance replacement priorities, TV (30%) and refrigerator (20%) are top on the list Based on this data, it could be suggested that potential information type DSM programs should be implemented for these two categories of appliances In the long-run, the standards and labeling policies could also be prioritized according to the appliance replacement projections determined through the surveys

Industrial Sector Energy Conservation Options

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[38] Once costs are available a benefit cost analysis of a water heater replacement program (through direct installation of solar water heaters in multi-story buildings) could be conducted to determine its economic viability

According to Energy Commission officials, industrial users consume approximately ten percent of the total electrical load Representatives of the Ministry of Industry and Trade indicate that industrial growth is 3 to 5 percent per year However, these values are all estimates, as few statistics are accurately kept But assuming that the ten percent industrial load is reasonable, the industrial load on a typical summer day is about 1000 MW (the summer daily consumption is approximately 10,000 MW) Some of these industries operate at night, while some, such as Nairit Chemical, operate twenty-four hours a day

In most industries, electric motors make up the greatest use of electric energy, often averaging between 60 and 70 percent of the total electric load Since motors are so plentiful and typically consume such a large amount of electric energy, it is important to examine motors carefully for energy savings opportunities There are two main improvements for motors

- Replacement with an energy-efficient motor
- Implementing a variable-speed drive

While these two technologies can have significant energy savings, each application has to be carefully examined to determine if technologies can be applied A general summary of these technologies follows

Energy-Efficient Motors

This technology is very basic, simply replacing an existing motor with a high-efficiency motor As motors age, they can lose some of their energy efficiency If the motor was a standard efficiency motor to begin with, the overall efficiency can be significantly lower than that of energy-efficient motors And if the motor has been rewound, the efficiency would be further reduced While replacing motors is very simple, the energy savings potential is dependent on the size of motor, the electricity rate, and the annual operating hours Since the premium for high-efficiency motors can be substantial, it is necessary to pay attention to these factors to optimize their implementation Payback periods of two to three years and longer are typical for upgrading an average-efficiency motor If the motor has been rewound or is extremely inefficient, the payback period would be shorter For instance, in the U S , average motors between 5 and 100 horsepower have a three-year or better payback when replaced with a high-efficiency motor if the average electrical rate is $0 04/kWh or greater and the motor operates at least 3,500 hours per year As a general rule, for motors 100 horsepower or greater, there is essentially no difference between a standard-efficiency motor and a high-efficiency motor Efficiency differences are normally between two to four percent, although with the smallest motors, the differences are greater

Many electrical utilities have encouraged the use of high-efficiency equipment such as motors by offering rebates to the customer to help offset the incremental difference in price between a standard- and a high-efficiency motor The question, of course, is how much of a rebate should be offered, so that it will encourage the industrial customers to purchase the higher efficiency motors, yet not negate the anticipated electrical savings on the electrical system This type of DSM program is dependent on what equipment is available in the Armenian market and the cost of that equipment It's possible that all motors would have to be imported to Armenia, so import tariffs would be relative But if standard efficiency motors are produced in Armenia and high-efficiency motors are not, the import tariffs added to the incrementally higher cost of high-efficiency motors would probably negate this option

Variable-Speed Drives

Variable-speed drives (VSD) (also called adjustable-frequency drives) are controls that monitor the motor load and reduce the energy to the motor, so that motor use is optimized This is especially effective for operations where the load varies significantly during the day These devices save energy but do not save electrical demand, since it is assumed that the motor still operates throughout its entire range of loads Similar to motor replacements, energy savings relate to the number of hours that the motor operates But more specifically, they are functions of the motor loads and the number of operating hours at each load Operations that require a constant speed are not good candidates for VSD, since the potential savings will be minimal Potential energy savings can easily be calculated, and many manufacturers provide computer programs to demonstrate the annual energy savings and the payback period Normally, the variable-speed drive equipment can be expensive, so it is important that the applications are carefully selected

Power Factor Correction (Reactive Power Compensation)

Using electrical energy is very basic, but it can differ from facility to facility "Power factor" is the term that is used to describe the "efficiency" of the electrical use Low power factors (below 0 95) can significantly add to the electrical demand placed on the power system For instance, if a customer has a load of one megawatt and a power factor of 0 95, the utility actually has to provide 1 05 megawatts of power to meet the load (1 divided by 0 95) But if the same customer had a power factor of 0 85, the demand would actually be 1 18 megawatts Therefore, the utility has to provide an additional 0 13 megawatts, for this one customer as a consequence of a low power factor Power factor correction requires an engineer to determine the current power factor and to design the appropriate capacitors to correct the load to at least 0 95

The power factor in most of the industries is low, as a result of old, inefficient equipment and because the industries operate at low, partial capacities (industries were designed to operate assuming full production, but now their production is around 10%) While providing capacitors may be expensive, this improvement's impact is immediate, lowering the electrical demand for the industry To encourage this improvement, the utility should give serious consideration to implementing a penalty in tariffs for industries that operate at sub-90 per cent efficiency levels Charging a penalty would provide the utility with additional funds and would also encourage the customer to make the necessary improvements themselves

Energy Audit Program

Industrial energy audits are offered by many utilities in DSM programs The cost of the audit is either paid for or subsidized by the utility This type of activity is very good at identifying the inefficient energy users in industries When implementing this type of program, several basic factors should be considered

1 The auditors should be certified or approved by the utility to determine that they are indeed qualified to conduct a complete and proper energy audit
5 The utility should establish the format of the audit report, so that the audits are as uniform as possible

6 The recommendations of the audit should be standardized as much as possible, in that similar recommendations in one facility should have similar savings and costs in other facilities
7 All audits should emphasize short-term improvements or those recommendations that have payback periods of one year or less

An energy audit program is really an identification program, in that it is intended to provided technical information to assist the plant management in deciding what systems or equipment should be improved or replaced To be successful, the audit program should also have a mandatory requirement that all improvements with a one year or less payback period be implemented at the industrial plant within six months of completing the audit If the plant management fails to follow through on this condition, they would be charged for the cost of the audit The important thing is to get the customer to implement the energy savings improvements

Commercial Sector Energy Conservation Programs

A significant opportunity for DSM activities is available at commercial and government buildings The commercial sector in Armenia has rapidly expanded in the last three years as evidenced by the presence of many newly-remodeled buildings that host restaurants, bars, cafes, banks, retail shops, and offices There are also numerous local and federal government buildings that offer opportunities for replicable energy efficiency projects Types of government buildings include schools, hospitals, elderly homes, orphanages, and office buildings Building envelope improvements, energy management systems, lighting, and water heating are types of activities for consideration in a DSM program

Prior to the Armenian energy crisis, the space heating needs of the majority of buildings were met by the district heating system (DHS) Entire buildings were heated by a piped radiator system The absence of mechanical controls meant that individual room temperatures were controlled through the use of windows and supplemental heaters

Currently, only a small portion of buildings are heated by the DHS, leaving the majority of buildings to be heated by individual room space-heating devices (exceptions are newly remodeled or constructed small commercial buildings that typically use electric-powered boilers) These devices are most commonly fueled by electricity or kerosene In some cases, space heating is also fueled by wood- or coal-burning stoves The existing space heating conditions are controlled by each room's occupants

The general physical condition of most buildings in Armenia is poor, largely due to the lack of maintenance The public sector buildings are in especially poor condition Scarce budgetary resources have meant that little or no building maintenance is being performed Many public buildings are characterized by windows and doors that are physically falling apart and do not close properly, allowing high levels of outside air infiltration

Building Envelope Improvements

Types of building envelope improvements include weatherization and repairs of doors and windows, caulking, and insulation of walls, ceilings, basements, and pipes Weatherization of windows and doors includes measures such as weatherstripping, replacing broken or missing glass, replacing missing or broken hardware, and adjustments for better fit and operation Caulking includes the sealing of window and door frames and other gaps/cracks in the exterior walls For the most basic levels of weatherization, activities include replacing broken or missing panes of glass and caulking the larger gaps in the building envelope The next level of weatherization involves installing weatherstripping This activity often requires adjusting or repairing windows and doors so that they operate properly This activity requires considerable carpentry and painting because of the existing poor condition of many of the windows and doors The cost of the repairs can add $50 to $100 or more to each window and door, greatly increasing the payback of weatherization However, without these repairs, the windows and doors would need to be totally replaced, at a much higher cost, some time in the future if the building is going to be continually functional and utilized

In general, basic levels of weatherization and caulking have payback potential of one to three years, and insulation paybacks range for eight to twenty years

Numerous studies over the last five years have been conducted on building envelope improvements in the FSU and EE Payback for implementing various energy efficiency measures are fairly consistent throughout these studies These paybacks are generally based on utilizing the DHS for space heating As the DHS is largely non-functional in Armenia, it would not be accurate to estimate potential energy savings using these studies

Specific to Armenia, RMA has implemented extensive weatherization projects and monitored the results over the last five years Over the last two years, these projects have focused on public buildings such as schools, hospitals, orphanages, and elderly homes The work activities have gone beyond basic weatherization to include necessary repairs to the windows and doors, which have increased the estimated payback periods The reported results include the following examples

Elderly House in Yerevan

<u>Actual Results</u>
Winter temperature inside weatherized rooms is higher by 8-10 degrees C
Heat losses from infiltration at windows were reduced by 91 8%
<u>Theoretical Results</u>
Energy savings for monitoring period = 536 5 million BTUs
Payback period = 4 75 years

Orphanage in Kharberd

<u>Actual Results</u>
Winter temperature inside weatherized rooms is higher by 5-8 degrees C
Heat losses from infiltration at windows were reduced by 90 3%
<u>Theoretical Results</u>
Energy savings for monitoring period = 457 5 million BTUs
Payback period = 5 6 years

School # 8, Yerevan

Actual Results
Winter temperature inside weatherized rooms is higher by 5-8 degrees C
Heat losses from infiltration at windows were reduced by 60%
Theoretical Results
Energy savings for monitoring period = 1 06 billion BTUs
Payback period = 3 6 years

Maternity Hospital #4, Yerevan

Actual Results
Winter temperature inside weatherized rooms is higher by 5-10 degrees C
Heat losses from infiltration at windows were reduced by 84 5%
Theoretical Results
Energy savings for monitoring period = 3 4 billion BTUs
Payback period = 1 16 years

By instituting a weatherization program for all commercial and municipal buildings in Armenia, it is estimated that substantial savings could be made Multilateral banks have provided funding for a number of building-related energy efficiency projects in the Former Soviet Union (FSU) and Eastern Europe (EE) In Armenia there currently is a World Bank-funded program, the *Armenian Social Investment Fund* An opportunity exists for a comprehensive building envelope improvement project that would target buildings serving the public This project would emphasize cost-effective energy efficiency improvements and necessary repairs to the building The funds for the work would be repaid through the savings generated by the building's lower energy costs

Energy Management Systems

Studies have shown that building controls and insulation improvements can result in savings at 3 to 5 year payback periods In buildings such as hotels which run on commercial basis, these savings are quite attractive Smart energy management systems can be installed by ESCOs in commercial buildings like hotels and bars, and implemented through performance guarantee based shared savings contracts This same principle could be applied for commercial lighting improvements in a wider range of buildings

Water Heating

Significant commercial/municipal users of hot water include public institutions such as hospitals, orphanages, and elderly homes, and commercial enterprises such as hotels, laundries, and food service firms

Energy Conservation in Municipal Sector

Street Lighting

Prior to the energy crisis in Armenia, street lighting was common throughout Armenia During the energy crisis, very little street lighting or public lighting of any kind was visible Over the past few years, as the supply of electricity has increased, essential streets and important public areas in Yerevan have been provided with lighting Street and highway lighting and the illumination of other public areas are the responsibility of local and national government entities that have scarce financial resources, limiting the amount of lighting provided and reducing the maintenance necessary to keep the systems in good operating condition

30% of Yerevan's 90 major streets have some level of street lighting, utilizing energy in-efficient hydrogen bulbs The remaining areas of Yerevan, as well as the rest of Armenia, have virtually no current street lighting As economic conditions improve in Armenia, more areas will gradually see street lighting restored, increasing the demand for electricity Yerevan's current street lighting schedule is restricted in hours of operation because of insufficient funds to pay for the energy consumption and miscellaneous expenses associated with maintenance and repairs The current lighting schedule is separated into winter and summer time hours

Winter hours	17 30-23 30
Summer hours	20 30-22 30

The Yerevan City Lighting Company (YCLCO) is responsible for the operation and system maintenance of, and payment for, electricity utilized for the street lighting in Yerevan The YCLCO is funded by the Municipality of Yerevan, which receives its funding form the Federal Government If YCLCO fails to pay for electricity, the local electric distribution will disconnect the service

The current annual electrical consumption for all 30 Yerevan streets provided with lighting is estimated by YCLCO to be 3,000,000 kWh RMA estimates that replacing the existing hydrogen bulbs with high-pressure, sodium-vapor bulbs could result in savings of 40% of the current consumption, or 1 2 million kWh annually

Water and Sewer

Water Supply System Electricity utilized in the water supply system can be separated into two categories the main supply system and building level pumps Water pumps supplying Yerevan account for 70% of Armenia's total water supply volume and consume a similar percentage of Armenia's electricity dedicated for water supply The city of Yerevan is located at an elevation of 900 to 1,450 meters above sea level Seven water pumping stations are located in elevations higher than Yerevan, and three stations are located at lower elevations The pumping capacity of all the stations combined is much higher than currently needed because of severe economic conditions that have resulted in most industries closing or operating at a much reduced capacity During the last ten years, water supply system maintenance and repairs have been minimal, resulting in severe system deterioration It is estimated that the water loss due to poor technical condition of the system is 60%-65 %

Yerevan water supply pumps work 24 hours/day all year and consume 220 million kWh/year A total water volume of 13,867 liters/second is supplied to Yerevan, 60% (8,100 liters/second) of which is supplied by the water pumping stations Yerevan Municipal Water engineers calculate that 24% of this amount (1,950 liters/second) could be supplied by a gravity-fed system, instead of electric pumps, resulting in savings of 24 million kWh/year A report prepared by the Municipal Water Utility also states that if the entire Yerevan water supply system was reconstructed according to an energy-efficient design, energy savings totaling 110 million kWh/year would result from decreased water losses, reductions to the amount of water supply required, and a more energy-efficient delivery system

The water pressure level supplied to Yerevan is purposely low to limit the amount of technical losses and reduce further damage to the network Because of the low water pressure, almost all buildings taller than 4-5 stories require supplemental water pumps There are 1,100 registered building pumps regulated by the water utility Their hours of use are 8-10 am and 6-8 pm, all year, and they consume 10,000,000 kWh/year There are also an estimated 1,000 unofficial building pumps, with their schedule of operation and electrical consumption unknown

Sewer System

Pumps for the Yerevan sewer system consume 14,000,000 kWh/year and work 24 hours/day year round

In June 1998, the World Bank approved a $30 million credit to Armenia to improve the Yerevan water supply system The project will (1) make emergency short-term improvements in the water supply system to improve the drinking water supply, (2) improve the efficiency, management, operation, and delivery of water and wastewater services for the Yerevan service area, and (3) lay the groundwork for sustainable involvement of the private sector in the overall management of these services in Armenia

The cost estimate prepared by the Yerevan Municipal Water Utility for total reconstruction of the water system is $246 million

D DSM Program Recommendations and Strategies

Based on the foregoing discussions, Table 6 8 summarizes the various actions and strategies that could be undertaken over the short- and long-term to implement energy efficiency improvements through DSM programs A balanced mix of different programs, end-use technologies, sectors, and strategies would be desirable

In the short-run (up to 2005), the major factors that will drive the choice of DSM strategies and policies are

- Armenia Nuclear Power Plant (Medzamor) will be in operation
- Energy efficiency equipment market is not fully developed
- Relatively smaller export market (due to technological and political barriers)
- High transmission and distribution, and commercial losses
- Focus of programs will be in Yerevan area

In the long-run (after 2005), the following characteristics of the sector will dictate the mix of DSM programs and strategies

- Armenia Nuclear Power Plant will not be in operation
- Energy efficiency equipment/appliance market will have developed because of market transformation
- A larger export market for electricity will exist
- Focus of programs will move from Yerevan to other areas of Armenia

In addition to specific DSM program implementation, other complimentary strategies have to be developed through energy policies Some of those steps are

- Information Dissemination and Education Strategies to increase awareness
- Compulsory Energy Audits
- Strengthening of Energy Efficiency Standards and Introduction of Labeling System
- Transition to Rational Cost-of-Service Based Tariffs and Collection
- Facilitating ESCO Businesses
- Establishment of a DSM Cell and training of its staff

These strategies are discussed in detail in Chapter 9

Table 6 8
Demand-Side Energy Efficiency Strategies and Recommendations

Primary Objective	Target End-Use Sector	Program Option and Mechanism	Target End-Use Technologies	Government or Utility Benefits	Consumer or Societal Benefits	Program Costs	Implementation Strategies and Possible Financing Mechanisms
Load Management DSM Shifting from Daytime to Nighttime	Residential Low Consumption (Low Income)	Time-of use (Day/Night) Tariff Voluntary	Space Heating, Hot Water Clothes Washing Ironing, Cooking Behavioral Change	1 Savings due to increased nuclear/ thermal generation efficiency 2 Extra power available for sale to neighbors during peak hours	Reduced bills	TOU Metering	1 Meters to be financed by the generation cost savings (and export revenue differentials) to be passed by the GenCos to DisCos 2 Meters to be provided under a World Bank program aiming to providing 1 p meters to 9% Yerevan Residential sector by 2001
	Residential High Consumption (High Income)	Time-of Use (Day/Night) Tariff Voluntary	Hot Water Clothes Washing, Ironing, Cooking Behavioral Change	1 Savings due to increased nuclear/ thermal generation efficiency 2 Extra power available for sale to neighbors during peak hours	Reduced bills	TOU metering	1 Meters to be partly financed by the generation cost savings (and export revenue differentials) and partly to be borne by the customers 2 Meters to be provided under a World Bank program aiming to providing 1 p meters to 9% Yerevan Residential sector by 2001
	Industrial such as bread factories	Time-of Use (Day/Night) Tariff Voluntary	Energy intensive industrial process Move from Peak shift to Off Peak Shift Operation	1 Savings due to increased nuclear/ thermal generation efficiency 2 Extra power available for sale to neighbors during peak hours	1 Reduced production costs 2 Increased competitiveness	TOU Metering	1 3 p meters to be provided to all of Yerevan under a World Bank program. 2 ESCO s could provide the 3 p meters with shared savings contract with the customers
	Residential High Consumption (High Income)	Time-of use (Day/Night) Tariff	Hot Water Replacement by Super insulated Heaters	1 Savings due to increased nuclear/ thermal generation efficiency 2 Extra power available for sale to neighbors during peak hours	Reduced bills	1 TOU Metering 2 Appliance Replacement	1 Meters to be financed by the generation cost savings (and export revenue differentials) and appliances to be borne by the customers 2 Meters to be provided under a World Bank program aiming to providing 1 p meters to 9% Yerevan Residential sector by 2001 3 Appliance manufacturer could provide incentives (recovered through increased sales)

	Residential	Rescheduling popular TV programs from evening (peak) to night	TV Behavioral Change	1 Savings due to increased nuclear/ thermal generation efficiency 2 Extra power available for sale to neighbors during peak hours	Reduced Bills		
Strategic Load Growth DSM	Industrial non operational Industries New Industries	Time-of use (Day/Night) Tariff	Industrial processes allow night shift operation only to the reviving industries give night kW load permit only	Savings due to increased nuclear/ thermal generation efficiency	1 Lower bills 2 Increased competitiveness for market	TOU metering	1 Meters to be financed by the generation cost savings (and export revenue differentials) and the cost of appliances to be borne by the customers 2 1 3 p meters to be provided to all of Yerevan under a World Bank program.
Strategic Energy Conservation DSM	Residential Commercial Government, Schools Hospitals	Lighting Appliance Vendor Development (CFL and Fluorescent lamps development)	Lighting	1 Reduced need for adding power plants in the future 2 Extra power available for sale to neighbors during peak and off peak hours	1 Reduced bills 2 Reduced expenses 3 Market Transformation	Vendor incentive	Foreign firms collaborating with local firms and local manufacturers provide the seed money
	Residential	Incentives and Loans	Water Heater Jackets	1 Reduced need for adding power plants in the future 2 Extra power available for sale to neighbors during peak and off peak hours	1 Reduced bills 2 Reduced expenses	Incentive	Incentives to be provided by the utility (distribution company)
	Residential	Information Program (through newspaper and other media)	Refrigerators TV (replacement of old appliances with new ones)	1 Reduced need for adding power plants in the future 2 Extra power available for sale to neighbors during peak and off peak hours	1 Reduced bills 2 Reduced expenses	1 Information program costs 2 Extra cost of efficient appliances	Government should be involved in information dissemination programs e g providing incentives to the media for including the energy efficiency agenda in their programming
	Residential	Direct Installation	Water Heater replacement with Solar Powered Water Heater	1 Reduced need for adding power plants in the future 2 Extra power available for sale to neighbors during peak and off peak hours	1 Reduced bills 2 Reduced expenses	Solar Powered Water Heater Cost	Cost of solar water heater could be paid for by savings arising out of zero electricity consumption ESCOs could get involved in this financing activity

	Commercial Government Buildings Schools, Hospitals	Performance Guarantee/ Shared Savings Programs	Controls Lighting improvements				ESCOs raise the money (through subsidized loans) and install the equipment
	Commercial Schools and Hospitals	Direct Installation	Building Weatherization				Funding through multi lateral development banks and subsidized loans
	Municipalities	Direct Installation	Water Pumping, Street Lighting	1 Reduced need for adding power plants in the future 2 Extra power available for sale to neighbors during peak and off peak hours	1 Reduced expenses of the municipality resulting in lower utility costs for the customers	Replacement Cost	ESCOs raise the money (through subsidized loans) and install the equipment. Investment recovered through performance guarantee based shared savings program.
	Industries	Energy Audits and Information, Incentives	Efficient Motors Variable Speed Drives	1 Reduced need for adding power plants in the future 2 Extra power available for sale to neighbors during peak and off peak hours	1 Reduced Costs 2 Increased competitiveness and larger markets	1 Energy Audit Cost 2 Replacement Cost	Agencies like ACAEE and other ESCOs could get involved in the energy audit actvities and do it free of cost with the assurance that they will be involved in the implementation process
	Industries	Direct Installation or Incentives/Rebates	Capacitors for Power Factor Improvement	1 Reduced need for adding power plants in the future 2 Extra power available for sale to neighbors during peak and off peak hours	1 Reduced Costs	Capacitor Cost	This type of program is expected to have very low paybacks ESCO s could purchase and lease capacitors to customers on a performance guarantee and shared savings basis

7 ALTERNATIVE SPACE HEATING STRATEGIES

A Natural Gas Supply Rehabilitation Plans

Prior to the 1988 earthquake and the subsequent energy crisis nearly 84% of Armenia was served by natural gas lines The annual consumption of 480,000 customers in the 1980s was approx 7 27 billion cubic meters The gas supply system is in extreme disrepair and requires substantial repairs [39] The Republic of Armenia has established a program to restore the natural gas supply system to its former level

Current Status of the Gas Supply System

Armenia is currently supplied 2 to 2 5 million cubic meters/day The following chart illustrates the customer mix

Customer Breakdown

power plants	1 64-2 05 mcm/day	(82%)
industry	0 226-0 3 mcm/day	(11 8%)
commercial and food production	0 058-0 1 mcm/day	(2 9%)
residential	0 044-0 055 mcm/day	(2 2%)
other	0 022-0 0275 mcm/day	(1 1%)

The current tariff is 56 drams/cubic meter

Restoration and Expansion Plan

The plan objective is to complete the supply system restoration by 2001 Modernization of the whole system is planned including utilizing modern technologies and equipment, and implementing structural changes and installing operational systems to ensure economical and efficient gas consumption The main requirements for restoring the gas supply system are security and the reliable collection of payments

The supply of natural gas will be restored to 100,000 citizens of Armenia by the end of 1998 30,000 citizens were reached last year By the year 2001, total lengths of gas supply piping are to be 10,000

[39] Only 10% is currently supplied of the total estimated annual gas demand of 16 billion m^3, as a result of pipeline blockages (en-route neighboring Republic of Georgia) and damages or payment problems Most of the gas goes to fuel power generation A newly-formed joint venture (with Russian and Italian firms) Armrosgazprom (*Hairusgazard*) has started to re-establish a gas supply to the housing sector As of early 1998, only 30,000 residential customers in *Nork* district, one of Yerevan s twelve districts have access to gas supply (it should be noted here that using gas fired space heaters in apartments that were not designed for them [insufficient ventilation] entails the potential risks of explosions also)

km, with 1,800 pressure regulation stations This restoration plan will rehabilitate the gas distribution network in 43 towns and 343 villages, and serve 483,000 customers

The total projected investment of the restoration plan is $78 million and the year by year projected expenditures are as follows

1998	$23 5
1999	25 9
2000	18 8
2001	10 2

There are no current marketing/promotional plans for expanding customer base as it is not believed to be necessary The projected future tariffs are unknown

B District Heating System Rehabilitation Plans

Background

The Armenian District Heating Systems were designed to provide space heat and hot water for Armenia Responsibility for system operation is spread amongst four groups the Ministry of Energy, City of Yerevan, provincial community organizations, and the power plants According to the "Fuel-Energitic Complex" report prepared for the the Ministry of Energy (July 1998), the system is comprised of three major thermal power plants (Yerevan, Vanadzor, and Hrazdan), a boiler house in Gumri, 10 regional heat supply stations in Yerevan, 23 large boiler houses, and hundreds of low-to-medium-capacity boiler houses MEF statistics from the "Expenditure Stabilization and Tariff Regulation" report show that during the 1980s

1 The three thermal power plants in Yerevan, Vanadzor, and Hrazdan provided consumers with up to 6 5 Gcal (7 56 billion kWH) of energy annually
2 The remaining thermal demand for Armenia was 15-17 million Gcal (17 5 - 19 8 bln kWh) and supplied by the other boilers listed above

The report also states that the current production of all the systems is 1 0 - 1 5 million Gcal (1 16 - 1 7 bln kWh)

Current Situation

The overall existing condition of the DHS, the extent of needed repairs, and accurate DHS rehabilitation cost estimates are unknown [40] Best-guess current cost estimates of DHS

[40] There is little opportunity for cost-effectively retrofitting Armenia s currently non-functional central heating system comprising of district heating from co-generation plants, from large heat only boiler houses, and small decentralized boiler houses (TACIS 1996) Lack of financial resources required for retrofits is also a major constraint

rehabilitation/upgrade range from US $1 5 - $2 billion Even if the DHS was functioning normally, many major components are near the end of their designed useful life and will require upgrading and/or replacement Even without accurate DHS rehabilitation cost estimates, the MEF understands the costs will be substantially above what the GOA would be able to finance The MEF currently believes the solution is to privatize the energy sector, and let the private market place establish tariffs sufficient to finance DHS rehabilitation and upgrades DHS rehabilitation/upgrade concepts currently being discussed within the MEF include two DHS options (1) rehabilitation of entire network, or (2) repairing only the portions of the network that are less damaged, and replacing the remaining portions of the network with a combination of systems such as de-centralized highly efficient boilers, heat pumps and geothermal sources The Armenian Chapter of the Association of Energy Engineers (AC/AEE) committee on heat supply has proposed to the MEF a plan to more accurately assess the condition of the DHS and to prepare DHS rehabilitation cost estimates The proposal includes excavating and inspecting representative portions of the system to determine the actual condition The proposal is being considered by the MEF

The status of the DHS in Armenia is that only two districts of Yerevan were served last winter Nor Sebastia/Lucashin and Nor Nork The tariff was 1,450/dram/sq meter/heating season There are no plans for expanding service areas for the upcoming winter

8 FINANCING STRATEGIES FOR ENERGY EFFICIENCY IMPLEMENTATION

A Internal Sources of Finance

Utility Financing

Attractive to utility because increases efficiency and lowers generation cost, program of incentives and rebates

Customer Financing

There are few sectors of the Armenian economy that are actually doing well and growing However, one of these is the commercial/retail sector There has been tremendous growth in the retail sector (shops, restaurants, hotels) over the past two to three years, mainly in Yerevan Banks are another growth sector The extent to which these facilities are considering energy (specifically electricity) use in making their purchasing decisions is unknown Energy costs can be a high percentage of operating costs for restaurants and other retail shops

One option would be to survey the retail/commercial sector to determine what their current awareness of energy efficiency is, and to tailor an incentive program for their needs Not much is known about their specific end-uses and equipment efficiencies An energy awareness and informational campaign undertaken by the distribution company would be one place to start It appears that these small to medium-sized establishments could afford to invest in energy efficiency improvements if convinced that these investments would pay for themselves in a short period of time

Financing through Exports

As was pointed out in Chapter 2 and 3, increasing energy efficiency through DSM programs would make power available to export to neighboring countries This is one of the compelling DSM objectives for Armenia At the current time, export opportunities are constrained because of political problems and non-payment issues However, assuming these can be worked out in the medium term, export earnings can be used to further increase the efficiency of electricity consumption in key sectors, such as the municipal/institutional sector At the current time, local governments are paying the cost of inefficient use of electricity If financing became available through export earnings, these public sector investments would benefit everyone through lower budgetary requirements in this sector

B External Sources of Finance

Donor Organizations

Donor organizations can play a crucial role in developing confidence in energy efficiency programs and projects Successful pilot projects can provide best-case examples and documentation of energy savings Information on current donor activities and interests in energy efficiency and other areas related to the energy sector are explained later in this Chapter These funding sources should be utilized to the maximum extent possible in planning energy sector directions and investments

ESCO Financing

Financing through Energy Service Companies (ESCOs) is one option for consideration in Armenia ESCOs in this context mean financing of energy efficiency improvements through a performance contract in which the savings are guaranteed and the investment is paid back through the savings For background information, a paper prepared for the Armenian International Energy Conference is included as Appendix - V This paper addresses the prospect of financing energy efficiency improvements through ESCOs in Armenia, including a discussion of barriers and prerequisites for successful private ESCO operation In this section, three ESCO models will be presented and their applicability to Armenia discussed

Private Sector Models

In the U S market, the majority of energy efficiency projects implemented by ESCOs are financed using private sector models for financing and implementation In some cases, the market was pushed through government incentives or regulation The ESCO itself can be several different types of firms (utility, equipment manufacturer, financial institution, A&E company or specialized firm) The common characteristic is that they all have private sector ownership that operates in a stable and predictable business environment In well-developed market economies, the barriers facing each type of firm will be the same In the private sector, the types of financing mechanisms that are used to implement energy efficiency projects include

- *Client Self-financing* - Using internal funding sources to implement projects
- *Client Debt Financing* - Borrowing the money to implement energy efficiency
- *Leasing* - Ownership of the equipment generally stays with the equipment provider for some period of time with an option to purchase at the end of the agreed lease period
- *Third-party financing with performance guarantees* - ESCO financing or bank financing that is paid back over some period and tied to the energy savings

Because of the many barriers (see discussion in Appendix - V), a solely private sector model faces unsurmountable constraints in the short run in Armenia A more realistic approach is one that combines public sector ownership with private sector ownership, or a public sector program with eventual privatization These models are discussed below

Public Private Partnership

In countries that are transitional and where both government plays a more dominant role in the market, such as Armenia, a mixed public/private effort to mobilize capital for energy efficiency may be more successful in overcoming the barriers Another way of characterizing barriers is to say that they are risks to the investor/financier The incentive for government involvement in encouraging energy efficiency is that it is a lower-cost alternative to increasing supply Government support will be crucial to reduce risks which are unacceptable to the private investor Due to existing market distortions, private investment in energy efficiency makes sense in only very limited circumstances

One method being used to overcome the risk of financing is to require sovereign guarantees to international financing institutions, which lowers the interest rate because of lower project risks For example, the World Bank and EBRD are the only financing organizations providing large-scale funding for energy system improvements in Russia The World Bank will provide funding only under the condition of a sovereign guarantee Russia has taken out loans for over $360 million for district heating system improvements to date, and is developing another $300 million loan EBRD is looking at a mechanism that would provide funding for energy improvements with a regional and municipal guarantee, but without a sovereign guarantee

Another mechanism by which funding is being provided for energy efficiency projects is through multi-project facilities to large foreign ESCOs In these projects, the multilateral development bank takes both a debt and equity position in the ESCO, which spreads out the project risk between the corporate ESCO and the bank Recently, EBRD approved loans to two ESCOs that will be operating in Russia (Honeywell and Landis & Staeffa) Other such loans are being considered for Russia and other countries of the FSU

A third model that involves the public sector in accepting project risks is one where the government (national, regional, or local) becomes a partner in a company that is established to undertake energy efficiency projects This model is being used in Russia in the Nizhny Novgorod region Here, the ESCO partners are the regional government, a foreign corporate partner and the bank All three have an equity stake in the company and an active role in overseeing its operation The regional government benefits through lower expenditures for subsidy payments in the residential and municipal sectors

Public Sector Model

In Ukraine, the government is establishing an ESCO to identify and implement industrial sector energy efficiency projects The ESCO financing is being guaranteed by the national government to EBRD There, the project risk is too great to attract private or public/private financing without a sovereign guarantee The ESCO that is established is supposed to be privatized within a two-year period, after receiving training and assistance from an EU technical consultant However, it is too early to tell whether this will be successfully completed within the two-year time frame

Potential Sources of Financing in Ongoing Programs

This section describes a number of ongoing activities in the energy sector and other sectors that could be tapped as a source for financing the DSM recommendations Each of the following programs was contacted regarding their interest in energy efficiency and, for the most part, responded very favorably Utilizing these programs/sources would leverage the impact of USAID energy sector funding

Caucasus Enterprise Fund

The Caucasus Enterprise Fund is a USAID-funded project being implemented by Shore Bank of Chicago It is comprised of a micro-lending program (loans under $1000), being managed by a Shore Bank subcontractor, Finca Bank, with offices in Washington, DC, and a small-to-medium lending program (loans up to $200,000) managed by Shore Bank itself Shore Bank is in the process of setting up an Armenian office All loans will be administered in Armenia through Armenian banks (i e , interested borrowers should apply direct to the Armenian banks), which are setting up application procedures and have full responsibility in approving loans Interest rates for these loans are expected to be in the neighborhood of 15% Eligible borrowers are restricted to small, private, local enterprises

Recommendations This Fund looks to be a potential good source for ESCO operating funds for implementing DSM projects using performance contracting USAID could provide support in the way of technical assistance to help develop bankable projects, including writing business plans if required, successfully filling out bank applications for Enterprise Fund loans, educating banks on the viability of the performance contracting method of financing projects, and managing projects such that loans are repaid USAID might possibly also provide funding in order to buy down interest rates for energy efficiency projects or to provide seed money for efficiency contracts such that borrowers would not be required to borrow 100% of the funds needed for implementing energy efficiency projects

Contact Susan Berger, ENI/ED/SB, Tel 202-712-4194 Ms Berger was very interested in the use of the Enterprise Fund for energy efficiency projects and said she would mention such projects to Shore Bank She was also enthusiastic about cross-cooperation across USAID programs and invited USAID to work with her to help evaluate how the Fund could be used in implementing energy efficiency projects

Eurasia Foundation

The Eurasia Foundation has grant and loan programs It takes applications for the grant program on an ongoing basis for both Armenian and US-based projects It has two grant programs the open-door grant system, which will entertain any kind of proposals, and the competitive grants program, which is tailored for particular sectors The Foundation also has a small lending program that is administered in Armenia

Contact Marsha McGraw-Olive, Eurasia Foundation, Vice President for Grant Programs, tel 202-234-7370, ext 114, Horton Beebe-Center, Eurasia Foundation, tel 202-234-7370, ext 132, Laurens Ayvazian, Eurasia Foundation, regional director in Yerevan, Mark Smith, USAID, tel 202-712-4512

European Bank for Reconstruction and Development

At present,the Energy Efficiency Unit (EEU) at the EBRD is not doing anything in Armenia, primarily because of the unsure political situation there Nonetheless, the Bank's policy may change at any time, and the EEU is very interested in any preliminary and/or background work that may be done by USAID and its contractors in the area of energy efficiency, and would review any project proposals that would take into account Bank policy as described below

In general, EBRD energy efficiency projects tend to be in the $5 to 20 million range, preferring larger projects because of high overhead costs For private sector risk projects, EBRD will provide up to one-third of the financing, for sovereign guarantee projects, EBRD will provide 80-100% of the financing but will also ask for some contribution by the local government

For example, as concerns a district heating project, assuming the system is municipally owned, EBRD would require a sovereign guarantee or, preferably, a private sector participant who would be granted concessionary treatment by the government to revamp the system In general, however, district heating projects are considered to be high-risk with low cash flow and a long project life cycle

Any sort of ESCO project of interest to the Bank would most likely be in the industrial sector in which energy efficiency is a component of the investment required The criteria for a good client would be a credit-worthy industry with audited accounts and significant hard currency earnings (as a rule, the amount of annual hard currency turnover for the industry should be equivalent to the amount borrowed) However, the Bank has found that industries in these countries have a weak cash flow and rely to a significant degree on barter

When considering the nature of possible future projects in Armenia, the EBRD EEU has a strong preference for private sector projects In order for them to consider a public sector project, there would have to be an urgent need and/or have a strong transition impact beyond the scope of the project The Bank is presently capital-constrained and not in the position to invest in a project simply for the sake of energy efficiency

Recommendations Despite rather stringent conditions for lending in Armenia, the EEU is very interested in becoming more informed about the energy efficiency situation in Armenia and pursuing projects there They are also quite interested in collaboration with other donor organizations EBRD should be either invited to the briefing in Armenia on the results of this report in September 1998 or should be provided a copy of this report USAID might want to pursue with the EEU the inclusion of an energy efficiency component for possible future industry restructuring loans that the Bank may develop in Armenia and provide pre-loan assistance in the form of accounting assistance and/or energy auditing

Contact Energy Efficiency Unit, EBRD (tel 44-171-338-6737)

Overseas Private Investment Corporation

OPIC disburses the other tranche of the Caucasus Enterprise Fund OPIC-administered Funds are to be used for very large projects of $1,000,000 or more and can be used by US companies doing business in the Caucasus Similar funds in other countries have been concentrated mostly in real estate or agribusiness The OPIC Caucasus Enterprise Fund should be operational by the end of September 1998

Recommendations Energy efficiency improvements could be incorporated into real estate projects using OPIC Fund loans USAID could provide technical assistance in the form of engineering work required to incorporate energy-efficient technologies in building renovation and/or construction

United States Energy Association

As of May 1998, no USEA-sponsored electric or gas partnerships are in place for Armenia The closest association appears to be between Armgaz and Western Kentucky Gas No USEA activities with the Armenians have covered energy efficiency or DSM Armenergo has been reorganized and separated into separate transmission, distribution, and generating companies There are about 30 generating companies The largest generating company, and the one to be privatized first (sometime "soon"), is the Yerevan City Network (contact Robert Nessaryan) Commonwealth Electric (contact William Poist, now retired) of Massachusetts was set up to make its first trip to Armenia to investigate a possible partnership this month, but the Armenians balked at having to switch to international accounting standards (supposedly because of wide-scale corruption and graft), so the trip was postponed Commonwealth is now undergoing restructuring and moving its corporate headquarters Poist has retired, so this project is on hold

A collection of retired Pacific Gas and Electric Company executives (including Charles Tadeossian and Wilmer Kapullian) are interested in working with the Armenians under a "virtual partnership" They would pull together a number of experts in various general management areas (billing, collections, accounting, etc) and arrange for a seminar in San Francisco with a follow up visit to a power plant This would be a very general program for electric, gas, distribution, generation, or transmission

Armgaz and Western Kentucky Gas Armenians made a pre-partnership trip to Kentucky in November 1997 Next a group of executives from Western Kentucky Gas were to go to Yerevan end of June 1998 to discuss more particulars of a partnership agreement This is still in the very preliminary stages

In conjunction with Hagler-Bailly's work in establishing an independent regulatory commission, two commission staff members spent one month with the Kentucky Public Service Commission in Frankfort, Kentucky, late last year In March 1998, some of the Kentucky staff, including one commissioner, went to Yerevan In May-June 1998, four Armenians from the staff were to return to Kentucky to work on regulatory issues

The World Bank

Energy Sector Unit for Europe and Central Asia The Energy Sector Unit is presently managing two loans Power Maintenance and Transmission and Distribution (T&D) The Power Maintenance loan will be completed in December 1998, the T&D loan is presently on hold (has not made it to the board yet) because of changes in the Armenian government A Power and Gas Restructuring loan has been examined as well as a Power Privatization loan It has been decided that at the present time there is no scope for a gas project, particularly considering the possible sale of transmission facilities to Gasprom The Privatization loan may go forward providing the Bank has good results with the T&D loan The Energy Sector Unit has decided that there has been too much damage to the district heating system from its long idleness to rehabilitate in a cost effective manner Therefore, a district heating loan is not presently being considered either In general, monies for energy projects are tight

However, the energy strategy for the Europe and Central Asia department is to include energy efficiency whenever possible In general, the best strategy is to approach the Environmental Sector Unit with energy efficiency suggestions, which will raise the funds, including "free" GEF money, and come to the Energy Sector Unit for implementation Now is a good time to try to identify grant money for pilot projects and the Environmental Sector Unit is the appropriate office to talk to (see below)

Recommendations

Contacts Salman Zaheer (T&D loan task leader - tel 202-712-1185), Jonathan Walters (tel 202-473-2468), and Jan Masterson (Power Maintenance loan task leader - tel 202-473-5005)

Environment Sector Unit for Europe and Central Asia The Environment Sector Unit is finalizing its National Environmental Action Plan (NEAP) for Armenia the last week of August This and the Lake Sevan Action Plan will be used to develop an Environmental Sector Loan, which is now in the pipeline The loan will include bilateral, GEF, and World Bank components The Bank is interested in including RMA findings on energy efficiency options for Armenia in both the NEAP and Environmental Sector Loan For example, GEF funds could be used to develop pilot programs in the housing sector or hospitals and schools as part of this loan The World Bank has identified the residential sector as the second highest polluter in Armenia (transportation being the first) It is also looking into heating options and the use of geothermal energy in the district heating system

At the end of October 1998, the World Bank will be on mission in Armenia The first week of the mission will be devoted to presenting the NEAP The second week will be devoted to identifying project components The World Bank has asked that USAID send a representative on this mission to help identify energy efficiency components In addition, the Bank is interested in sending its counterparts in the Ministry of Environment to the USAID/RMA briefing on DSM options for the least-cost plan to be held in September in Yerevan

Recommendations One no-cost option for USAID is to provide the Environmental Unit the recommendations in this report as candidates for inclusion in its upcoming Environmental Sector loan, particularly pilot project ideas in the housing sector for GEF funding USAID could also leverage some of its funds by providing technical assistance in the development of energy efficiency components of the loan, beginning with the participation in the World Bank mission to Armenia in October and examination of heating options, including geothermal, for Armenia

Contact Sari Soderstrom, World Bank, Environment Sector Unit for Europe and Central Asia (tel 202-473-8726)

9 LONGER-TERM ENERGY EFFICIENCY POLICIES FOR ENHANCING SUSTAINABILITY

In the short term, because of the lack of financial incentives from utilities or the government, and the absence of funds available with the customers to implement energy-saving measures, there is a strong need for international development agencies, or even private sources (given the potentially large market) to step in and provide the money for implementing DSM projects Pilot-scale or demonstration projects in the end-use areas identified in the sections above should be conducted

In the long term (year 2000 onwards), however, several policy tools have to be formulated to make the DSM strategy sustainable, some of which are described in the following sections

A Information Dissemination and Education Strategies

This strategy applies to all sectors Customers have to be made aware of energy efficiency products, their costs, and their advantages through various ways, including TV, radio, and newspapers Seminars and conferences about energy efficiency should also be held at regular intervals to keep the energy efficiency community at pace with the advances in the field Electric utility can also help in disseminating information in the form of informational fliers along with regular monthly electric bills to the customers

B Compulsory Energy Audits

Mandatory audits of industrial facilities and large commercial and government buildings could be made a part of the Energy Efficiency Law currently being legislated Facilities not meeting the minimum efficiency standards should be penalized if they take no corrective action within a reasonable period of time

C Energy Efficiency Standards and Labeling

Energy efficiency standards (minimum efficiency, maximum consumption, or maximum losses) ensure that the products (end-use equipment and appliances) in the market move from an inefficient to efficient stock This market transformation takes place through a market push activity, where the manufacturers are required to produce efficient equipment and "push" them into the market However, to do this, adequate testing facilities for energy efficiency are required Also, the standards should be progressive in nature and keep pace with the technological advances going on in the field

Energy efficiency labels, which could be either voluntary or mandatory, are also helpful in creating a demand or "market pull" for energy-efficient appliances The labels have to be properly designed to convey the information to the consumer who can then make a decision based on that information Comparative labels seem to be more effective than endorsement labels in developing countries

D Government-Supported Research and Development of Energy-Efficient Appliances

The Armenian government should provide funding for research in energy efficiency improvements, either at their national laboratories or to the private manufacturing sector Experience shows that technologies have to be adapted to the local conditions and factors (such as power quality) and locally developed technologies are often more cost-effective in saving energy than is imported equipment

E Rational Tariffs and Collection

In 1997, the average tariff was raised by 40%, from 3 3 cents per kWh to 4 6 cents per kWh (Oxford Analytica, 1998, USEIA, 1996), with lower prices for the low-income customers [41] Because tariffs are a heavy burden to most Armenian families, there is growing public discontent (RFE/RL, 1998) as the cost of production is less than half this figure (average generation cost is about 2 3 cents per kWh according to ERC, 1998) The margin is unjustifiably high and is a result of disproportionately large transmission and distribution (T&D) losses The sector, however, still has to rely on government subsidies because the total supply costs to customers are in the range of 6 cents per kWh

Government is currently focusing largely on regulation of energy tariffs Enforcement of billing and bill collection discipline, including disconnections for non-payments, have led to increases in total collections from 35% in 1994 to 80% in 1998, resulting is reduction of commercial losses

For the promotion of the country's energy efficiency, the application of economically substantiated principles is of key importance The principles of tariff policy are associated with ensuring a long-term development of the energy sector and absolute exemption of discrimination among different groups of population The first principle is connected to the demand for particular types of fuel and investigation of the sector development and planning Three main methodological approaches are used in the formation of tariff policy

Accounted costs only retrospective indexes of sector activities are used Tariff resulting from this approach is limited to distribution of average costs among consumer groups, without taking into consideration development projects, investment requirements, and potential prices

Economic costs changes in scope and structure of demand among different groups of consumers is taken into consideration, as well as change in demand on the basis of long-term, seasonal, and daily indexes Such items, as amortization of fixed assets, expenses on ecology, and safety of working conditions are also included in economic costs The main component of the economic cost based approach is the calculation of incremental costs of primary energy sources (gas, mazut, water, nuclear fuel, etc) The economic cost based approach has limitations, which are characteristic for medium-term (3-5 year) forecast methods

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[41] Nevertheless the decision to raise electricity prices was made in accordance with recommendations by the World Bank and other international lending institutions (USEIA 1996)

Marginal costs this is the most improved method of determining long-term costs in developed countries, which takes into account, in addition to the costs mentioned above, such items as the present fuel cost (including dynamic rent, possibility of price contingency of fuel in the market), maximum growth of demand, marginal costs of generation, transmission and distribution of an additional unit of energy, inter-departmental interaction of fuel prices, regulation of load schedule, and energy saving

F Establishment of a DSM Cell

As seen in other developing countries embarking on the DSM scene, it is always prudent to form a dedicated group of energy experts who are responsible for designing, developing and implementing DSM programs This DSM cell could be formed within the utility, ideally the distribution utility which has direct interactions with the customers The cell usually comprises of staff with backgrounds in energy engineering, energy audits, benefit-cost analysis, financial analysis, and customer interaction Over time, the DSM cell members should be trained in the use of DSM state-of-art software programs (such as DSManager and IRPManager) that are commonly available in the market

G Facilitating ESCO Businesses

Consumers must be aware of energy supply and demand alternatives and relative costs in order to make informed decisions, including decisions about energy efficiency In order for an ESCO market to develop, energy prices must be high enough for investment in energy efficiency to be profitable During this transition period to a market economy, there are many distortions in the energy market Instead of subsidizing inefficient energy use, the governments (federal, regional, and local) would be better off raising energy prices and only subsidizing energy for those who truly cannot afford market prices The higher energy costs would encourage people to invest in energy efficiency, and make ESCOs sustainable and profitable In the short run, it may be necessary for the public sector to take an active role in demonstrating the effectiveness of energy efficiency investments

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RESIDENTIAL END-USE SURVEY REPORT

by

Mary Worzala and Dr Zohrab Melikyan

PREFACE

The residential end-use survey was designed and implemented in middle to late summer 1998, as one piece of the analysis that RMA conducted in the Demand-Side Management Options Analysis for USAID Because of time and budget constraints, the analysis on the survey is not as complete as could be accomplished with the data which that gathered in the survey With the overall contract expiration date of September 30, this report is being included as an appendix to the main DSM report Additional analysis may be conducted between the issuance of the draft and the final issuance of the DSM report The results contained herein may be modified with this additional analysis

The report's co-author, Dr Zohrab Melikyan, President of the AEE Chapter and Professor at the Institute of Architecture and Construction, led the survey team in Yerevan Dr Melikyan, in particular, played a crucial role in recruiting the surveyors, directing the field activities, and in the data input design Without the contributions of several other individuals in Yerevan, the survey would not have been possible Mr Araik Zakaryan, who designed the database and supervised the data input, and Dr Gourgen Melikyan, who assisted in troubleshooting with the database, deserve special mention

We hope that this survey will provide a significant and useful contribution to the policy dialogue within the energy community The conclusions are strictly those of the authors

I INTRODUCTION

As one portion of the DSM analysis, RMA conducted a survey of 1000 residences in Yerevan This was an important aspect of the work, since almost half of electricity is consumed in the residential sector It is important to understand the end-uses of electricity and the timing of residential electricity use in order to be able to determine whether there are possibilities to either shift the timing or reduce the amount of electricity consumed in the residential sector The overwhelming contribution of the residential sector to electricity demand is due to several factors peculiar to Armenia of the 1990s

1 Others sectors, particularly the industrial sector, are not functioning at a normal level Therefore, the total electrical consumption is very low This makes the share of residential electricity use relatively higher than in previous times In more normal times, prior to this transition period, the residential sector consumed 25-30% of electricity

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2 Electricity is the only reliable energy source available to the residential sector in Armenia these days Natural gas was formerly imported for providing district heating in the winter, and for cooking and space heaters in the residential sector The supply of natural gas has been very limited in Armenia for the past several years because of difficulties in Georgia that have interrupted supply, and payment problems The limited amount of natural gas being imported currently, is being used almost exclusively by the thermal power plants

3 The district heating system has been inoperative for several years, which has led to a dominant reliance on electricity for space heating This contributes heavily to a much higher winter demand for electricity than in the summer

The primary purpose of conducting the survey is to understand the current situation of electricity use in the residential sector There is very little data available regarding the specific components of end-use electricity in the residential sector Historically, residential electricity use was not metered at the apartment level, and collections were not strictly enforced With electricity being the dominant energy source available to the residential sector, the survey is intended to identify the largest end-uses and those end-uses coinciding with the system peak loads This data will be used to design residential demand management programs

This survey is unique in Armenia by virtue of its comprehensive nature and scope With its heavy reliance on electricity for all end-uses, and increasingly rigorous metering and collections system, the energy situation is also unique to countries of the former Soviet Union Payments for electricity consume a very high percentage of household income However, as other transitional economies move closer towards cost of service tariffs, energy becomes a more important issue at all levels of society In this way, Armenia may be viewed as a case study with some applicability to other transition economies

2 DESCRIPTION OF THE SURVEY METHODOLOGY AND THE SAMPLE

The survey format was developed in an iterative process with RMA staff, the survey team (led by Dr Zohrab Melikyan), and key persons within the Armenian energy community First, the key issues and questions that were to be addressed were discussed and a sample survey developed After considerable review, the survey was tested on a small sample of apartments in Yerevan Some revisions were made based on the field testing, and the survey form was finalized The final survey is shown as *Figure 1*

The sample size selected for the survey was 1000 dwellings, which reached a population of close to 4,000 inhabitants The sample size was selected in part to accommodate time and budgetary constraints Four types of buildings were selected as being representative of the most common types of residential buildings in Yerevan Residential building "representativeness" includes characteristics such as age of the building, number of stories, construction material (concrete block or tufa), and location in the city

The types of buildings and the number of surveys conducted in each survey category are as follows

Single-Family Homes	100 Surveys
4-6 Story Multi-Family Buildings	300 Surveys
9-12 Story Multi-Family Buildings	300 Surveys
14-16 Story Multi-Family Buildings	300 Surveys

Once the survey design was finalized, a meeting was held with the surveyors to explain the survey questions and to train them on how to conduct the survey This was done so that the manner in which the questions were asked would be consistent, and to make sure that the surveyors understood the questions Dr Zohrab Melikyan selected and trained all of the surveyors, many of whom were graduate students at the University of Architecture and Construction Locations for conducting the surveys were selected, including streets and specific apartment buildings, in order to get the desired mix of buildings and residents (The locations are identified in the maps in Section 3 of this Appendix)

The surveyors completed all of the surveys over a period of three weeks in July 1998 Surveys were conducted in person with an adult resident of each apartment surveyed On average, surveyors needed to make contact with four apartments in order to complete one usable response (25% response rate) Thus, in order to complete 1,000 surveys, the surveyors made contact with people in 4,000 dwellings The surveyors encountered considerable resistance, since people in Armenia are not accustomed to being asked to provide such information, and were suspicious of the reasons given for conducting the survey Many of the residents refused to give income data In addition, the survey is quite comprehensive and took 15 minutes to 1/2 hour to complete each one Surveyors walked through the apartments to record data on appliances Survey data was hand-recorded on a survey form in Armenian and transferred manually to an English survey form (see Figure 1) The accuracy and completeness of each survey was verified by Dr Melikyan prior to compiling the results

Figure 1
Armenia Residential End-use Electricity Consumption **SURVEY**

1	Address of the building/House	Str NO ap No				
2	Numbers of stories of the House					
3	Ownership of the house	self-owned, rented, state –owned, other				
4	Type of the house	multi-story, single family,				
5	Orientation of the house	S-N	W-E	SE-NW	SW-NE	
6	Floor of location of the apartment	Mid, Last				
7	Number of rooms of the apartment / house					
8	Living/ Total surface of apartment	m^2 / m^2				
9	Height of apartment	m				
10	Total Volume of apartment	m^3				
11	Total surface of external walls	m^2				
12	Total surface of windows	m^2				
13	Glazing rate of the apartment					
14	Number of glass panes	single / double				
15	State of windows	Weatherized / Non Weatherized				
16	Construction of walls	Concrete blocks, Tufa stone				
17	Thickness of walls	m				
18	Heat transfer coefficient of walls	$Wt/m^2 °C$				
19	Number of people living in the apartment					
20	Number of people being at home simultaneously	day / night				
21	Time of day of maximum consumption of electricity	**6-8^{00}**	**8-10^{00}**	**10-12^{00}**	**12-14^{00}**	**14-16^{00}**
		16-18^{00}	18-20^{00}	20-22^{00}	22-24^{00}	0-2^{00}
22	Average monthly consumption of electricity	kWh				
23	Average monthly electricity bill	Drams				
24	Maximum monthly consumption of electricity	Winter kWh / Summer kWh				
25	The average temperature in the apartment	Winter , °C, Summer °C				
26	The average income of the family	dram				
27	Use of renewable energy Sources					
28	Use of natural or liquid gas	(monthly consumption)				

29 Who maintains the lighting of common areas	
30 Who pays for common areas lighting bill	
31 If you had extra money which electrical appliance would you replace first	
32 If night electricity rate is cheaper, how would you use it	
33 Is your house connected to city gas distribution system	yes/no
34 Have you centralized gas supply	yes/no
35 Is your house connected to the district heat supply system	yes/no
36 Is your apartment supplied by heat	yes/no
37 Would you use more electricity than usual at night (23^{00}-7^{00}) instead of day (7^{00}-23^{00}) if the tariff for electricity was	2 o o 0 o o 75% of daytime tariff---------------yes, no
38 If the answer 35 is "yes" do you need any supplemental Heating in your apartment	yes/no

Electricity Consumption

Type of El appliances	Total Installed power, W,	Power , used simultaneously, W	Hours of simultaneous use of Energy		Duration of simultaneous use of Energy, h/day		Total use of energy, kWh/day	
			Summer	Winter	Summer	Winter	Summer	Winter
1 Lighting								
2 Heating								
3 Hot water								
4 TV								
5 Computer								
6 Audio-Center								
7 Refrigerator								
8 Pumps								

9 Air conditioner								
10 Elevators								
11 Fans								
12 Electric stove								
13 Mixer								
14 Flat-iron								
15 Vacuum cleaner								
16 Floor cleaner								
17 Kitchen combine								
18 Washing machine								
19 Other								
Total								

All of the data was input by the graduate students into Excel spreadsheets designed to capture most elements of the survey Each survey was entered into its own worksheet, with a "totals" worksheet by street name and type of building Street totals were compiled into a totals worksheet for each building type The totals worksheets are shown in *Figures 2* through *5*, one for each building type Analysis of the survey was done by RMA and is included in this report Budget and time limitations did not allow for a complete analysis of the survey data, i e regression analysis, correlation of variables, variance analysis, etc The full database is available from the authors of this report

Figure 2 Energy Consumption for 100 Single Family Homes, Yerevan (100 surveys)

Properties of apartments							
Numb of rooms in apt	Living surface m^2	Total surface m^2	Total volume m^3	Glazing rate average	Numb of glass panes	heat transf coeff of walls $W/m^{2o}C$	Number of habitants in apart
334 total	6603 5 total	9424.4	27168	0 1731 average	1 61 average	0 8948 average	469 total

TotaL monthly consum of elect	Total monthly elect bill ArmDram	Total income of the families	onnectio to gas D/S	Have you centr gas supply	Connect to DHS **	Is your apart supplied by he t	Use of night elect. at the d t *** t riff
24510 reported	470630 reported	1714960 reported	65	2	4	0 0 00 ⁄	43 75 %

Need in supplementary heating
0 0 00 ⁄

Energy Consumption kWh/kWh ****													
Appliances	Hours of day												
	24-2	2-4	4-6	6 8	8-10	10-12	12 14	14-16	16 18	18 20	20-22	22 24	Total
1 Lighting	0 76	0 76	0 75	0 4	0 8	0 6	0 6	4 26	19 02	56 68	64 12	54 56	202 3
	2 11	2 11	2 1	0 1	0 62	3 48	3 48	3 48	3 58	11 7	51 66	60 98	145 2
2 Heating	30 24	30 23	30 23	34 9	39 9	30 9	31 9	34 9	27 9	48 2	43 4	36 9	419 6
	0	0	0	0	0	0	0	0	0	0	0	0	0
3 Hot water	7 6	7 5	7 6	11	13 382	12 692	8 11	9 322	11 882	20 762	14 304	6 66	130 614
	7 6	7 6	7 6	11	15 482	10 702	7 11	10 14	14 382	24 644	12 904	7 66	136 624
4 TV	1 14	1 14	1 13	0	0 32	4 14	3 1	4 8	8 554	32 106	38 266	31 18	126 876
	1 97	1 97	1 97	0	0 32	4 44	3 74	5 74	9 104	29 656	37 558	32 33	128 798
5 Computer	0	0	0	0	0	0	0 018	0 018	0 018	1	2	0	3 054
	0	0	0	0	0	0	0 018	0 018	0 018	2	1	0	3 054
6 Audio-Center	0	0	0	0	0 02	0 548	1 012	2 824	3 791	2 344	0 688	0 464	11 691
	0	0	0	0	0 02	0 398	0 862	2 974	3 941	2 344	0 688	0 484	11 711
7 Refrigerator	11 772	11 772	11 772	12 026	12 026	12 242	12 322	12 322	12 322	12 242	12 026	12 026	144 871
	17 3	17 267	17 267	17 562	17 562	17 642	17 642	17 642	17 642	17 642	17 682	17 563	210 283
8 Pumps	0 18	0 18	0 18	0 18	0 18	0 18	0 18	0 18	0 18	0 18	0 18	0 18	2 16
	0	0	0	0	0	0	0	0	0	0	0	0	0
9 Air conditioner	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0 5	0 8	0 8	0 8	0	0	0	2 9
10 Elevators	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0
11 Fans	0	0	0	0	2 13	0 309	0 132	0 866	0 34	0 106	1 693	0	5 466
	0	0	0	0	2 13	0 261	0 12	0 867	0 34	0 236	1 463	0	5 417
12 Electric stove	3	3	3	3	5 61	10 23	1 94	17 298	16 856	3 66	3 1	0	70 694
	0	0	0	0	1 11	5 43	1 19	19 298	14 336	3 82	3 1	0	48 284
13 Mixer	0	0	0	0	0	0 032	0 356	0 48	0 092	0 075	0 052	0	1 087
	0	0	0	0	0	0 064	0 3801	0 48	0 116	0 075	0 084	0	1 1991
14 Flat-iron	0	0	0	0	1 412	4 056	1 76	2 232	2 876	4 443	5 52	0 82	23 188
	0	0	0	0	1 412	4 224	1 76	2 4	2 605	4 583	5 52	0 82	23 324
15 Vacuum cleaner	0	0	0	0	1 416	0 148	0 486	0 298	0 326	1 166	0 096	0	3 935
	0	0	0	0	1 416	0 148	0 468	0 298	0 326	1 165	0 096	0	3 917
16 Floor cleaner	0	0	0	0	0	0 368	0 045	0	0	0 36	0 16	0	0 933
	0	0	0	0	0	0 368	0 045	0 128	0	0 36	0 16	0	1 061
17 Kitchen combine	0	0	0	0	0	0 092	0	0	0	0 04	0	0	0 132
	0	0	0	0	0	0 092	0	0	0	0 04	0	0	0 132
18 Washing machine	0	0	0	0 18	1 434	2 614	0 834	1 206	1 06	2 5	1 144	0 53	11 502
	0	0	0	0 18	1 434	2 638	0 834	1 206	1 06	2 304	1 144	0 53	11 33
19 Cooking	0	0	0	0	0	0 096	0	0	0	0	0	0	0 096
	0	0	0	0	0	0 096	0	0	0	0	0	0	0 096
Total	54 59	54 57	54 56	61 69	78 63	79 2[illegible]	62 8	91	105 2	184 9	186 6	143 3	1167 128
	28 88	28 85	28 84	28 83	41 4	50 [illegible]	38 45	65 47	68 25	100 6	132 9	120 4	733 2301

1 Energy total consumption per sq m/per day	Winter	0 17522949	kWh/m²da
	Summer	0 11103669	
2 Energy total consumption per cub m/per day	Winter	0 04259158	kWh/m³per
	Summer	0 02698874	
3 Energy total consumption per person/per day	Winter	2 52097596	Wh/pers d
	Summer	1 5974512	

) Distribution system
**) Distribution Heating system
) Day time
**) Winter kWh / Summer kWh

Figure 3 4 to 6 STORY BUILDINGS Total Energy Consumption in 300 Selected Apartments in Yerevan (300 surveys)

Properties of apartments

N mb of rooms in apt.	Living s rface m²	Total surfac m²	Total ol me m³	Glazing rate a erage	N mb of glas pane	heat transf oeff of wall W/m² C	N mbe of habitants in part.
586 total	9209.97 total	16343	43350 19	0.30 rage	1 74 ge	1 08 a erage	1083 total

Total, monthly cons m. of elect.	Total monthly lect.bill ArmDram	Total income of the families	Connection to gas D/S	Ha e you mr gas s pply	Connect. to DHS **	Is you apart. pplied by heat	Use of night elect. at the d t. *** ta iff
59994 r ported	1157575 r ported	3851350 reported	269	0	259	135 45 00%	31 76 %

N ed in supplementary heating	
114	84 44%

1 Energy consumption per sq m/per day	Winter	0 3566786	kWh/m²day
	Summer	0 180692	
2 Energy consumption per cub m/per day	Winter	0 0757782	kWh/m³day
	Summer	0 0383677	
3 Energy consumption per person/per day	Winter	3 0332392	kWh/pers day
	Summer	1 635777	

) Distrib tion sy t m
**) Distribution Heating system
***) Day time
****) Winter/S mmer kWh/kWh

*Energy Consumption kWh/kWh (estimated/calculated by surveyors) *****

Appliances	24-2	2-4	4 6	6-8	8 10	10-12	12 14	14-16	16 18	18 20	20-22	22 24	Total
1 Lighting	0 78	0 78	0 78	3 14	9.44	1 72	1.44	2.4	34.842	109 11	111.85	85 74	362 022
	1 68	1 67	1 67	0.38	2 76	1 72	1.44	2.4	2.82	7 76	82 7	98 62	205 62
2 Heating	68	67	67	110 76	138 37	103 33	99 51	107.31	131.86	245 54	257 16	171 01	1666 868
	0	0	0	0	0 14	0	0	0	0	1.4	0	0	1 64
3 Hot water	3 6	3 6	3 6	8 98	18 215	14 933	21.447	30 1	29 59	80 17	74.449	11 11	299 794
	0	0	0	6 18	21 925	21 853	23 567	13.23	24 08	57 38	72 329	9 56	250 104
4 TV	0 72	0 72	0 75	0 06	4 5825	5 92	3 5	3 175	11 015	59 565	65.53	45 99	201 6276
	0 97	0 97	0 97	0 06	4 3225	6 04	3 06	2 845	6 88	43 985	62 68	46 995	179 7775
5 Computer	0	0	0	0	0	0	0	0.5	0 6	0	0	0	1 1
	0	0	0	0	0	0	0	1	0 1	0	0	0	1 1
6 Audio-Center	0 11	0 11	0 1	0 36	1 995	1 53	2 773	2 153	3 614	2 656	3.368	1.954	20 723
	0 11	0 11	0 11	0.2	1 66	1 98	2 673	2 631	3 379	2.446	3 158	1.899	20 356
7 Refrigerator	29	28 9	28 9	28.856	28.856	28 856	28 976	29.216	29.216	29.216	29.216	29.216	348 424
	46	46	46	45.844	45.844	45 844	45.844	45.844	45.844	45.844	45.844	45.844	550 596
8 Pumps	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0
9 Air conditioner	0	0	0	0	0	1	0	0 5	1 3	1	1	0 5	6 3
	0	0	0	0	0	0	0 198	1.34	1 115	1 69	0 6	0	4 943
10 Elevators	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0
11 Fans	0	0	0	0.575	6 3235	1.928	0 921	1 654	0 91	2 834	1.213	0 002	16 3605
	0	0	0	0 575	6.4895	1.833	0 921	1.473	1.07	2 724	1 177	0 002	16 2645
12 Electric stove	0.2	0.2	0.2	3.95	39 7	24.416	21 635	38.82	60.544	101 09	32.921	3	326 672
	0.2	0.2	0.2	3 95	40.85	19 366	15.835	42.17	53.515	96.586	16.925	1 5	291 297
13 Mixer	0	0	0	0 13	0 069	0 072	1 096	0.403	0 016	1.31	0 054	0	3 15
	0	0	0	0 13	0 069	0 072	1 096	0.4185	0 025	1.285	0 054	0	3 1495
14 Flat-iron	0 1	0 1	0 1	1.48	3 895	13 62	6 75	8.292	9.886	18.261	12.443	4 376	79 303
	0	0	0	1 64	6 725	13.24	7 14	6 602	9.826	17.991	9 623	2 556	75 343
15 Vacuum cleaner	0	0	0	0 515	3 919	6.274	3 585	0 737	0.82	1 06	0 506	0	17 416
	0	0	0	0 515	3 735	6 358	3 697	0 625	0.82	1 06	0.489	0	17 299
16 Floor cleaner	0	0	0	0 08	0 409	1 319	0 034	0 308	0 15	0 365	0.272	0	2 937
	0	0	0	0 08	0 414	1 375	0 022	0 308	0 15	0 365	0.272	0	2 986
17 Kitchen combine	0	0	0	2	1	0 13	0 05	0 035	1 13	3 565	3 085	0	10 995
	0	0	0	3 5	7 5	0 13	0 05	0 035	1 13	1 565	6.485	0	20 395
18 Washing machine	0	0	0	0.264	3 746	4 091	3 399	3 84	3 195	2 096	1 012	0 533	22 176
	0	0	0	0 232	3 667	4 306	3 377	3 174	3 032	2.87	1 012	0 566	22 236
19 Cooking	0	0	0	0	0	0	0	0	0	0	0.24	0	0 24
	0	0	0	0	0	0	0	0	0	0	0.24	0	0 24
Total	102 5	101 4	101 4	161 2	260 5	209 1	195 1	229 4	318 7	657 8	594 3	353 4	3284 998
	48 96	48 95	48 95	63 29	146 1	124 1	108 9	124 1	153 8	265	303 6	207 5	1663 2465

Figure 4 9 to 12 STORY BUILDINGS Total Energy Consumption in 64 Selected Buildings/303 Apartments in Yerevan (303 surveys)

Properties of apartments

Numb of rooms in apt	Living surface m²	Total urface m²	Total volume m³	Glazing rate average	N mb of gla s panes	h t tr nsf oeff of wall W/m² C	Number of habitants in apart
731 total	11479 29 total	20290 81	64760 64	0 27 aver ge	1 97 average	2 18 average	1204 total

Tot L monthly consum of elect	Total monthly elect bill ArmDram	Total income of the families	onnectio to gas D/S	Have you centr ga supply	Connect to DHS **	Is yo r apart supplied by heat	U e of night elect at the d t *** tariff
70886 reported	1392518 reported	3376000 reported	265 87 46%	2 0 66 %	290 95 71%	103 33 99%	38 37 %

Need in supplementary heating	
96	93 20 %

1 Energy consumption per sq m/per day	Winter	0 273623	kWh/m²da
	Summer	0 170248	
2 Energy consumption per cub m/per day	Winter	0 067359	kWh/m³da
	Summer	0 036688	
3 Energy consumption per person/per day	Winter	2 608801	Wh/pers d
	Summer	1 623191	

) Distribution system
) Distribution Heating system
) Day time
) Winter kWh / Summer kWh

*Energy Consumption kWh/kWh (estimated/calculated by surveyors) *****

Appliances	Hours of day												
	24-2	*2-4*	*4-6*	*6 8*	*8 10*	*10-12*	*12 14*	*14-16*	*16 18*	*18 20*	*20-22*	*22 24*	*Total*
1 Lighting	3	2 9	2 9	25 006	21 946	0	0	0 78	26 795	108 9	126 2	95 191	413 626
	3 84	3 83	3 83	16 675	1 2	0	0	0	0 04	4 42	71 43	104 08	208 34
2 Heating	11 74	11 73	11 73	60 55	66 68	46 4	48 4	60 1	78 66	213 7	305 7	233 45	1138 69
	0	0	0	0	0	0	0	0	0	0	0	0	0
3 Hot water	3 5	3 6	3 6	12 16	44 62	14 74	14 6	17 29	23 045	95 19	105 1	34 107	371 304
	0 9	0 89	0 89	10 16	66 36	11 74	10 67	16 04	27 073	86 11	84 66	22 336	325 711
4 TV	1 87	1 87	1 87	0 436	6 825	7 676	3 696	1 33	6 266	66 02	82 21	60 054	203 866
	1 99	1 99	1 99	0 436	7 125	7 636	3 756	1 23	2 42	41 26	70 54	63 495	203 866
5 Computer	0	0	0	0	0	0	0	0 46	0 4	0 2	0 9	0	1 96
	0	0	0	0	0	0	0	0 46	0 4	0 2	0 9	0	1 96
6 Audio-Center	0 02	0 01	0 01	0 382	0 419	0 944	2 732	2 991	3 683	4 494	4 977	2 062	22 624
	0 001	0 007	0	0 502	0 729	1 014	2 762	2 761	3 403	4 469	5 184	2 024	22 856
7 Refrigerator	25 1	26 1	26	25 192	25 477	25 677	25 68	25 68	25 577	26 7	25 27	26 192	304 338
	50	50	49	60 015	49 915	60 015	60 02	60 02	60 015	60 32	60 1	50 016	699 415
8 Pumps	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0
9 Air conditioner	0	0	0	0	0	0 03	0 03	0 03	0 03	0 03	0 03	0 015	0 195
	0 04	0 06	0 05	0	0	0 1	0 17	4 17	1 52	2 02	1 215	0 155	9 49
10 Elevators	0	0	0	0	0 15	0	0	0	0	0	0 05	0	0 2
	0	0	0	0	0 15	0	0	0	0	0	0 05	0	0 2
11 Fans	0	0	0	1 263	6 667	1 942	1 441	0 273	2 251	6 436	3 851	0 397	23 51
	0	0	0	1 423	6 062	2 298	0 877	0 262	2 261	5 994	3 339	0 427	22 933
12 Electric stove	0	0	0	33	79 26	24 32	23 04	17 83	55 818	186 3	89 46	9 92	618 9725
	0 66	0 66	0 66	30 86	75 91	17 73	27 68	18 16	48 853	167 4	63 94	8 78	641 2926
13 Mixer	0	0	0	0 012	0 668	0 31	0 523	0 064	0 423	1 561	0 362	0 016	3 9275
	0	0	0	0 012	0 612	0 31	0 293	0 054	0 333	1 388	0 362	0 016	3 3785
14 Flat-iron	0	0	0	2 032	7 13	7 636	1 873	5 805	4 842	20 31	8 991	3 229	61 748
	0	0	0	2 032	5 79	7 483	1 38	6 435	4 717	18 59	10 48	2 594	59 501
15 Vacuum cleaner	0	0	0	0 59	5 345	2 698	1 178	1 001	0 72	2 385	0 43	0 01	14 357
	0	0	0	0 59	5 976	4 025	0 926	1 001	0 72	2 369	0 43	0 01	16 037
16 Floor cleaner	0	0	0	0 14	0 946	0 3	0 008	0 01	0 05	0 687	0 03	0	2 171
	0	0	0	0 14	0 996	0 3	0 008	0 01	0	0 689	0 03	0	2 173
17 Kitchen combine	0	0	0	0 11	0 22	0 01	0 05	0	0	0 2	1 5	0	2 09
	0	0	0	0 11	1 22	0 01	0 05	0	0	0 2	1 5	0	3 09
18 Washing machine	0	0	0	3 177	8 133	3 45	1 679	1 046	0 52	7 401	0 661	0 108	23 174
	0	0	0	0 177	8 135	3 45	1 466	1 286	0 622	8 136	0 601	0 108	23 879
19 Cooking	0	0	0	0	0	0	0	0	0	0	0 2	0	0 2
	0	0	0	0	0	0	0	0	0	0	0 2	0	0 2
Total	45 23	45 1	45	161	273 4	135 8	124 7	124 6	228	738 5	756	463 8	3140 997
	57 43	57 4	56 4	112 1	220 2	106 1	99 95	100 9	142 3	382 5	365	254	1954 322

Figure 5 14 to 16 STORY BUILDINGS Total Energy Consumption in 64 Selected Buildings/ 300 Apartments in

Properties of apartments

Numb of rooms in apt	Liv ng surface m^2	Total surf ce m^2	Total vol me m	Glazing rat	Numb of glass panes	heat transf oeff of wall W/m^2 C	Number of habitants in apart
836 total	12921 01 total	24246 22	66836 08	0 25 average	2 00 average	2 19 average	1248 total

Tot L monthly cons m of l ct	Total monthly elect bill ArmDram	Total income of the families	onnectio to gas D/S	Have yo c ntr g s s pply	Conn ct to DHS **	Is your apart supplied by heat	U e of night elect at the d t *** tariff
2593696 reported	1732681 report d	4808146 reported	132	0	301	66 18 67%	37 67 %

Need in supplementary heating
20 36 71 /

Energy Consumption kWh/kWh (estimated/calculated by surveyors)

Appliances	24-2	2-4	4-6	6 8	8 10	10-12	12 14	14-16	16 18	18 20	20-22	22 24	Total
1 Lighting	1 1	1 1	1 1	11 9	16 24	0 24	0	0	19 36	117 2	134	102 45	404 64
	3 08	3 08	3 08	6 04	1 01	0 6	0	0	0	2 44	82 06	120 37	220 76
2 Heating	9 84	9 8333	9 8333	111 8	242 7	151	79 9	95	96 7	366 4	497 3	267	1937 33
	0	0	0	0	0	0	0	0	0	0	0	0	0 00
3 Hot water	3 54	3 5333	3 5333	15 86	33 6	28 65	30 26	33 36	47 76	139 6	95 09	25 595	460 32
	3 2	3 2	3 2	13 56	40 37	25 8	22 9	32 36	37 48	119 9	83 37	24 02	409 36
4 TV	0 9	0 9	0 9	0 2	3 78	8 24	3 146	1 16	6 27	70 91	84 11	60 795	240 30
	9 84	9 83	9 83	0	3 5	7 09	3 496	1 26	4 85	56 49	75 69	64 631	218 96
5 Computer	0	0	0	0	0	0 18	0 36	0 46	0	1 86	2 42	0 62	6 80
	0	0	0	0	0	0 6	0 28	0 34	0	1 7	2 42	0 62	5 76
6 Audio-Center	0	0	0	0 49	2 207	1 844	3 434	7 094	3 997	2 223	3 946	1 813	27 06
	0 08	0 08	0 08	0 412	2 198	2 081	2 321	7 186	5 069	2 083	3 825	1 717	27 13
7 Refrigerator	26 14	26 13	26 13	26 172	26 17	26 17	26 17	26 17	26 17	26 17	26 17	26 172	313 99
	48 34	48 33	48 33	48 178	48 48	48 67	48 62	48 37	48 27	48 27	48 28	48 178	579 85
8 Pumps	0	0	0	0	0	0	0	0	0	0	0	0	0 00
	0	0	0	0	0	0	0	0	0	0	0	0	0 00
9 Air conditioner	0	0	0	0	0	1	0	0 5	1 24	1	1	0 5	5 24
	0	0	0	0	0	0	1 71	3 51	6 48	2 66	0 12	0 12	13 50
10 Elevators	0	0	0	0	3	3	3	3	6	3 06	0	0	21 06
	0	0	0	0	3	0	0	0	6	0 1	0	0	9 10
11 Fans	0	0	0	0 809	4 332	6 734	0 94	0 991	1 44	2 949	2 188	0 419	20 80
	0	0	0	0 809	4 516	7 278	0 88	0 381	1 6	2 399	1 894	0 213	19 97
12 Electric stove	0	0	0	25 9	57 32	37 63	107 6	101 8	103 2	98 96	49 84	6 76	588 80
	0	0	0	22 9	55 62	32 18	108 1	96 6	99 9	76 54	44 77	7 75	642 27
13 Mixer	0	0	0	0 078	0 826	0 697	0 275	1 834	1 861	1 13	0 639	0 11	7 45
	0	0	0	0 06	0 826	0 583	0 26	1 86	0 852	1 121	0 709	0 128	6 38
14 Flat iron	0	0	0	1 16	7 016	7 771	6 18	5 5	5 47	9 01	25 27	3 892	71 27
	0	0	0	1 159	9 276	6 661	5 73	6 09	6 66	9 316	21 62	3 3	68 80
15 Vacuum cleaner	0	0	0	0 435	7 323	4 385	0 602	0 06	0	0 615	0 541	0	13 75
	0	0	0	0 436	7 119	4 386	0 602	0 06	0 01	0 646	0 586	0	13 63
16 Floor cleaner	0	0	0	0 37	1 486	0 61	0 01	0 17	2 62	0 6	0 67	0	6 34
	0	0	0	0 37	1 486	0 61	0 01	0 17	1 82	0 92	0 67	0	5 96
17 Kitchen combine	0	0	0	0 546	4 61	1 401	1 125	0 06	4 54	7 887	0 12	0	20 29
	0	0	0	1 046	5 23	1 392	1 125	0 06	2 78	8 147	0 12	0	19 90
18 Washing machine	0	0	0	0 126	6 268	6 447	3 636	0 359	0 8	2 907	6 45	0 34	26 33
	0	0	0	0 1	6 373	6 68	2 665	1 442	0 55	3 217	6 684	0 34	26 84
19 Cooking	0	0	0	0	0	0 441	0 16	0 16	3 38	0 46	0 4	0 12	6 12
	0 08	0 08	0 08	0 082	0 082	0 4	0 082	0 242	1 792	0 342	0 362	0 202	3 83
Total	1 52	41 50	41 50	195 84	416 88	286 24	266 56	277 61	329 69	652 88	929 14	496 47	4176 83
	6 62	64 60	64 60	94 15	189 06	144 71	198 47	198 81	222 11	334 06	372 07	271 49	2218 79

		Winter / Summer		
1 Energy consumption per sq m/per day	Winter	0 32	kWh/m^2day
	Summer	0 17	
2 Energy consumption per cub m/per day	Winter	0 06	kWh/m^3day
	Summer	0 03	
3 Energy consur ption per person/per day	Winter	3 36	kWh/pers da
	Summer	1 78	

) Distribution system
) Distribution Heating system
) Day time
) Winter kWh / Summer kWh

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3. DESCRIPTIVE CHARACTERISTICS OF THE SAMPLE

Location of Buildings

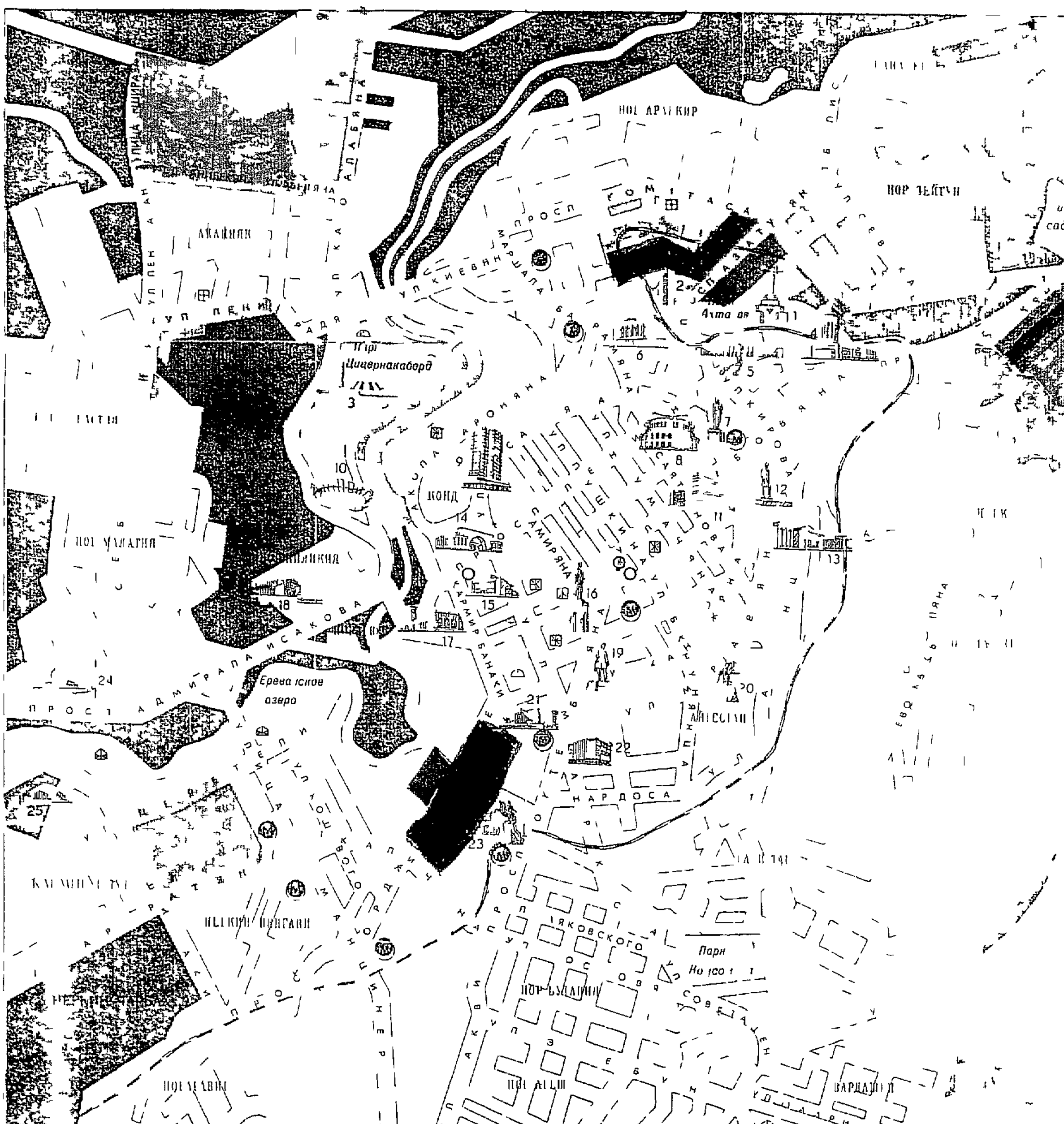
The buildings were selected to be representative of different geographical areas of the city within the four types of buildings selected The city of Yerevan is quite dispersed and has varying topography with some areas of the city exposed to windy conditions at various times of the year Also, Yerevan's share of total electricity consumption is the largest in Armenia, about 30% Generally, the high-rise, multi-story apartment buildings are found in the outlying areas of the city, with lower-story buildings in the city center Single-family homes can be found throughout the city

Income distribution cannot be generalized by area of the city, since apartments were assigned, in past years, more on the basis of status on the waiting list or proximity to a workplace It would not be uncommon to find all levels of income in the same apartment block Although formerly State-owned, the majority of apartments in Yerevan are currently privatized, including almost all of the apartments surveyed Another factor in the selection was connection to those portions of the city's district heating system which are operational

The map in the following page shows all of the buildings surveyed in the city Following are the districts included in the survey by building type, total population of Yerevan, and sample size

Districts Included in Survey	Ajapniak, Avan-Arinj, Davitashene, Kanaker, Nerkine Shengavit, Nor Malatia, Nor Nork, Nor Sebastia, Nor Zeitun
Population of Yerevan	1 2 million (1996 Armenia Human Development Report,UNDP)
Sample Size	3,994 people
Usable Responses	1000 dwellings

Single	4-6
12-16	9-12



General Characteristics of the Dwellings Surveyed

The residents of the 1000 dwellings surveyed were asked certain questions regarding energy use characteristics as well as general characteristics of the apartment and its residents These characteristics have been used in the analysis to better understand residential electricity use and to determine which elements have the greatest impact on energy use Some general characteristics of the sample are reported in *Table 1*

Table 1
General Characteristics of Sample

	Single-Family	4-6 Stories	9-12 Stories	14-16 Stories
Average Number of Bed Rooms	3 34	1 95	2 41	2 79
Average Number of Persons/Dwelling	4 59	3 61	3 97	4 16
Number of Persons/Dwelling - Range	1-12	1 11	1-11	1 11
Average Size (square meters)	94 2	54 5	67	80 8
Total # of Persons in Survey	459	1 083	1 204	1 248
Typical Construction Material [1]	Tufa 89% Concrete 11%	Tufa 69% Concrete 31%	Concrete 100%	Concrete 100%
Average Glazing Rate [2]	17%	30%	27%	25%
Number of Window Panes [3]	1 61	1 74	1 97	2 0

Notes
1 Tufa, a volcanic rock, is a common building material in Yerevan It has varying densities and good thermal conductivity
2 Glazing Rate is the proportion of surface area of the windows to surface area of the outside walls, expressed as a percentage
3 Number of window panes is an average of all windows

Single-family homes are on average the largest in size and have the highest occupancy levels In the multi-story buildings, the average size of the apartments increased over time, a pattern consistent with the data shown in *Table 1* The larger buildings were built more recently The range of inhabitants is quite large, however, the average is consistent with data from other sources, e g TACIS Buildings Report, November 1996 showed a mean urban family size of 4 5 persons

Single-family homes and 4-6 story buildings were constructed of both tufa and concrete block, while the larger buildings were all of concrete block construction This is attributable mainly to the age of the buildings, where tufa was used almost exclusively as a

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building material in buildings constructed prior to the 1960's in Armenia The typical height of the buildings increased over time, i e the 14- to 16-story buildings are newer than the 9- to 12-story buildings

The data also shows that the newer the building, the more likely that the windows are double-paned rather than single-pane While double-paned windows are generally more energy-efficient than single-pane windows, it is also widely observed that in the countries of the former Soviet Union building maintenance has been neglected, consequently, the construction does not hold up well over time Large cracks between the window and the frame, missing glass panes, and ill-fitting windows and doors are common in Armenia and elsewhere Residents were asked in the survey if they had weatherized their windows, and very few indicated that they had

Surveyors recorded the thickness of the outside walls for each apartment surveyed, as reported below in *Table 2*

Table 2
Wall Thickness Percentage by Building Type

Wall Thickness	Single-Family	4-6 Story	9-12 Story	14-16 Story
Less than 30 cm	10%	1%	18%	15%
30 cm	7%	30%	82%	65%
40 cm	35%	43%	None	15%
50 cm	38%	8%	< 1%	5%
60 cm	2%	18%	None	None
More than 60 cm	8%	None	None	None

As seen in *Table 2*, there is greater variation in outside wall thickness in single-family homes than in the multi-family apartment buildings This is due partially to the construction materials used (tufa vs concrete blocks) and to the standardization of building designs The higher-story buildings were built according to the standard Soviet construction norms in use throughout the former Soviet Union

Income and Electricity Expense Characteristics

Residents were asked to report their average monthly family income, however, a very significant number declined to give this information The percentage not reporting monthly income is as shown

Single-Family	45%
4-6 Story	24%
9-12 Story	53%

40

14-16 Story 31%

Even for those who did report average monthly income, the reported figure is highly suspect Residents are not likely to report all of their monthly earnings because of concerns over tax liability Many residents have unreported sources of income, such as work done for unrecorded cash payment, or money sent from relatives and friends outside of Armenia It is still an interesting number to evaluate and compare to official statistics For comparison, in the 4th quarter of 1997, average monthly wage was reported to be 8,924 drams in the state sector and 20,775 drams in the non-state sector This is the most recent data that was available (Armenia Economic Trends, May 1998) Reported income data from the survey is shown in *Table 3*, is much lower than the official data

The survey also contained a question about average monthly electricity bill Residents in general seemed very aware of their electricity use and its cost Almost all reported the monthly cost Even when residents declined to give their monthly income, they willingly reported the amount paid for electricity When the billing is compared to income, one can see that, at least as reported, electricity costs are a high percentage of the monthly income However, as noted above, income is undoubtedly under-reported

Table 3
Family Income and Electricity Expense Characteristics

	Single-Family	4-6 Stories	9-12 Stories	14-16 Stories
Average Monthly Income per Dwelling (drams)	31,181	16,892	22 658	23 116
Average Monthly Income (drams)	6,805	4,680	6 275	5,559
Average Electricity Bill per Dwelling (drams)	4,705	3,859	4 596	5 776
Average Electricity Bill per Capita (drams)	1,025	1,069	1,157	1,388
Electricity Expense as % of Income	15%	23%	20%	25%

Note 500 Armenian drams = US$1

It is difficult to draw any conclusions regarding income and expense characteristics since many of the residents did not report income The average income in the table above is determined by only those apartments that did report income The reported monthly family income figures ranged from less than 5,000 drams to more than 100,000 drams There seemed to be no correlation in the data between reported income and type of building, most likely because of the way that apartments were assigned in the past However, the average size and average bedroom numbers data *(Table 1)* is consistent with the average income data *Table 3* High income residential customers lived in larger homes and vice versa Electricity consumption (bill) for each category is also consistent with the size of the homes as well as with incomes (reported), with the exception of simple family homes As expected, the electricity expense (as a share of income) was the highest for low income customers (4-6 stories), similar to that observed in other countries

4 ELECTRICITY USE CHARACTERISTICS

Electricity consumption was determined in two ways First, residents were asked if they knew what their monthly electricity consumption was, as well as their monthly electric bill The value that residents reported as their average monthly consumption was converted to average daily consumption per dwelling This reported consumption is compared to electricity consumption, which was calculated by asking questions about specific appliances and their hourly use Since the survey differentiates between summer and winter usage in appliances, electricity consumption is calculated for the two periods as well These values are compared in *Table 4* below

Table 4
Average Electricity Consumption (kWh)

	Single-Family	4-6 Story	9-12 Story	14-16 Story
Per Capita Total Daily Consumption				
Reported	1 78	1 85	1 96	2 38
Calculated				
Summer	1 60	1 54	1 62	1 76
Winter	2 52	3 03	2 61	3 35
Total Electricity Consumption per square meter per day (calculated)				
Summer	11	18	17	17
Winter	18	36	27	32

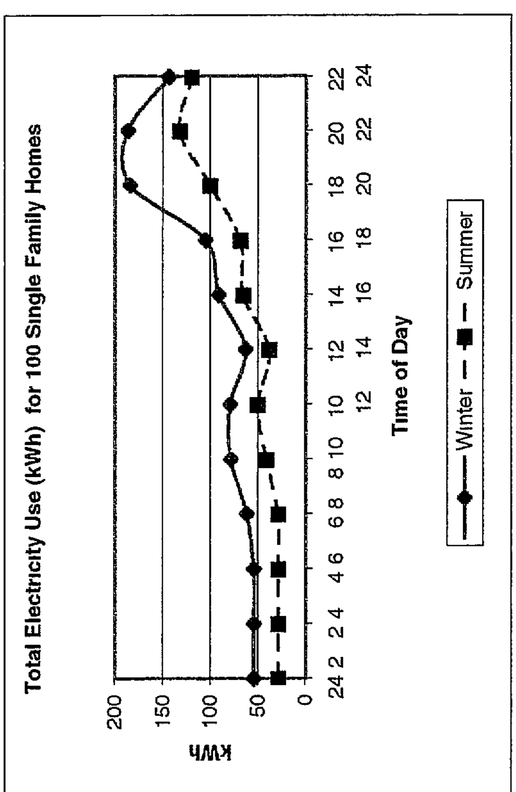
In all of the building types, the reported electricity consumption falls between the calculated summer and winter consumption values This is an indication that residents have a good awareness of how much electricity they are consuming

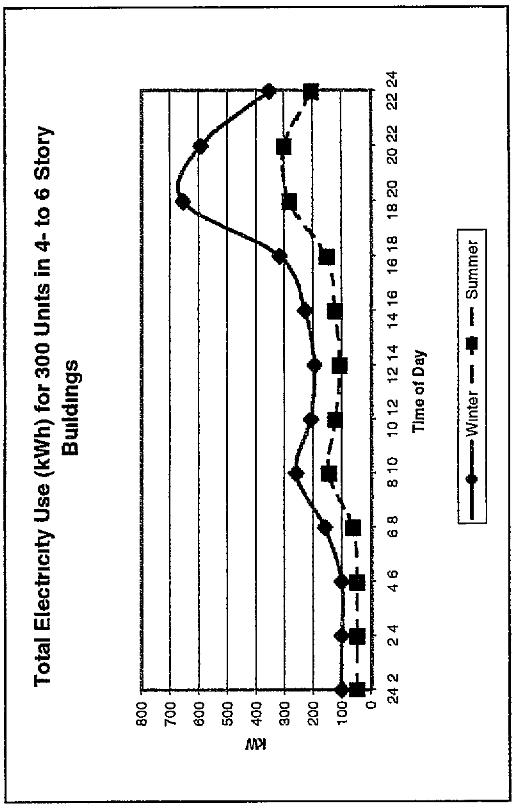
Time of Electricity Usage

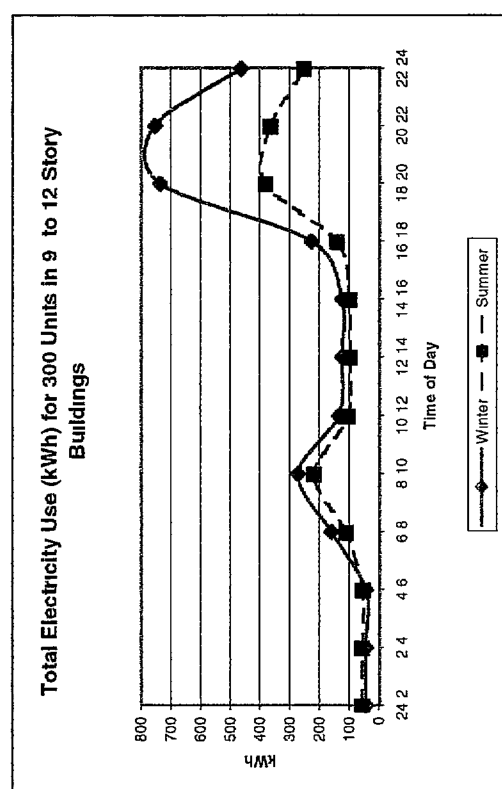
In addition to the overall consumption levels, it is also important to look at the time of usage Several graphs below show the picture of the timing of electricity consumption One graph per building type is displayed, which shows both summer and winter usage on the same graph It is interesting to note that the time-of-use patterns are relatively similar in summer and winter, but that the magnitude of consumption is much higher in the winter, presumably because of heating and additional lighting needs

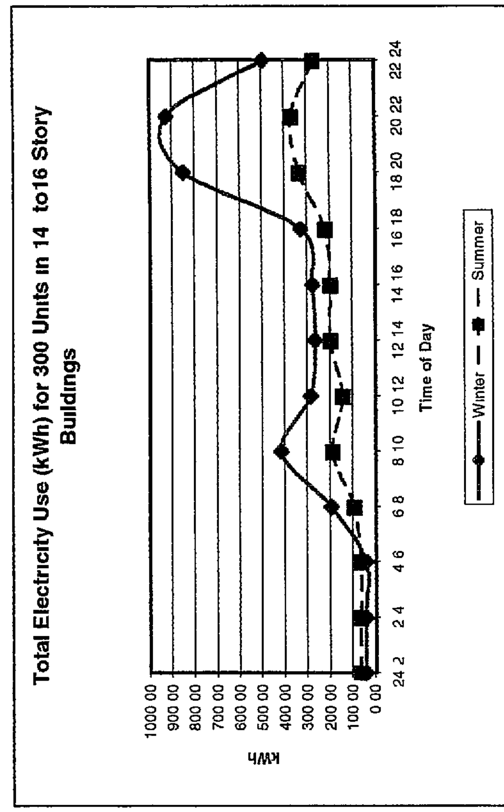
On each of the graphs, there are two peak usage periods that are evident The first is gradually rising electricity use between 6 and 8 am, with an intermediate peak occurring between 8 and 10 in the morning This is the period when people are getting ready for work in the morning and beginning daily activities in the household The second peak corresponds to the end of the work day, with electricity use rising in the 4-to-6 pm period to its daily peak of around 8 to 10 pm After 10 pm, electricity usage begins to drop off as people go to bed

If the summer and winter usage between the building types is compared, the difference in the summer and winter peaks is much higher in the 14- to 16-story building types In general, the difference is mostly due to the load required for space heating The difference in this building type may be a result of the fact that a smaller percentage of buildings of this type that were included in the survey are connected to operational district heating networks, or using natural gas heating This issue is discussed more fully in Section 6


Total Electricity Use (kWh) for 100 Single Family Homes
kWh
200
150
100
50
0
24 2
2 4
4 6
6 8
8 10
10 12
12 14
14 16
16 18
18 20
20 22
22 24
Time of Day
Winter
Summer


Total Electricity Use (kWh) for 300 Units in 4- to 6 Story Buildings
kW
800
700
600
500
400
300
200
100
0
24 2
2 4
4 6
6 8
8 10
10 12
12 14
14 16
16 18
18 20
20 22
22 24
Time of Day
Winter
Summer


Total Electricity Use (kWh) for 300 Units in 9 to 12 Story Buildings
kWh
800
700
600
500
400
300
200
100
0
24 2
2 4
4 6
6 8
8 10
10 12
12 14
14 16
16 18
18 20
20 22
22 24
Time of Day
Winter
Summer


Total Electricity Use (kWh) for 300 Units in 14 to16 Story Buildings
kWh
1000 00
900 00
800 00
700 00
600 00
500 00
400 00
300 00
200 00
100 00
0 00
24 2
2 4
4 6
6 8
8 10
10 12
12 14
14 16
16 18
18 20
20 22
22 24
Time of Day
Winter
Summer

5 APPLIANCE USE

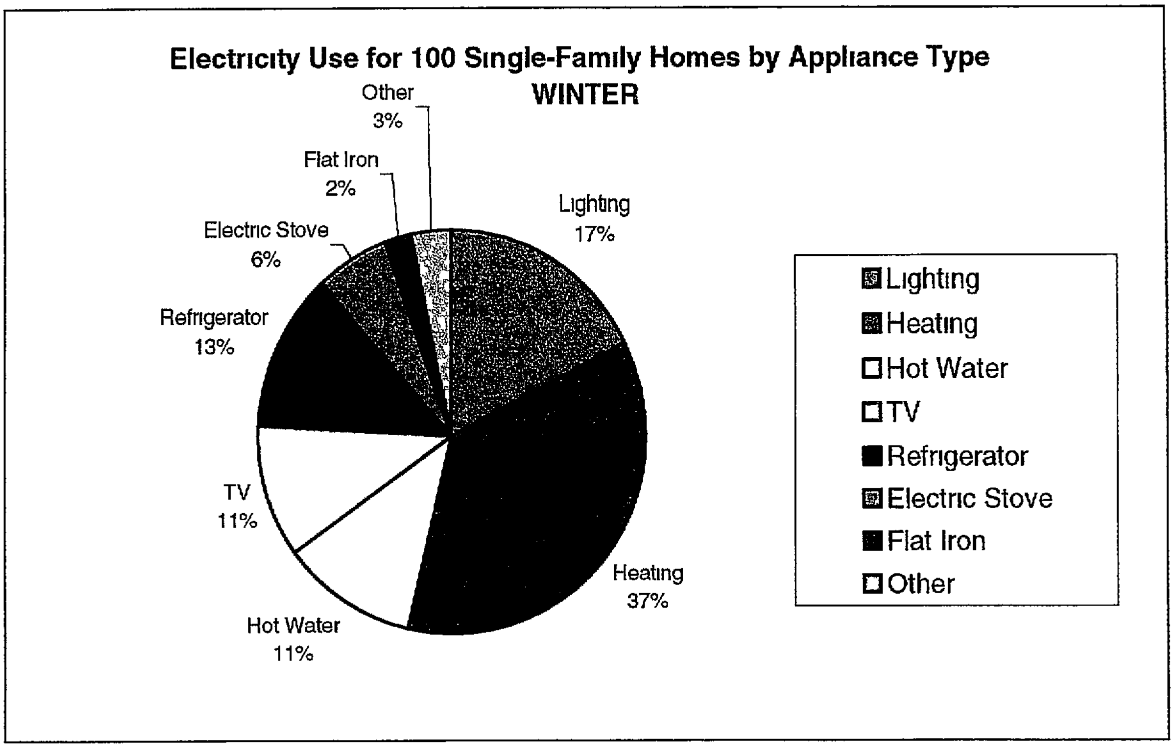
One of the major objectives of the survey was to determine which appliances are currently in use, their penetration rates, and their hours of use This data will be used to design DSM programs which will have the greatest cost-effectiveness and meet the other DSM objectives Residents were asked in the survey about their usage of 16 appliances, plus an "other" category The only item reported in the "other" category was electricity used for cooking These values have been included in the "electric stove" category Residents were also asked about electricity use for elevators and for water pumping, but no one reported any expense for these uses

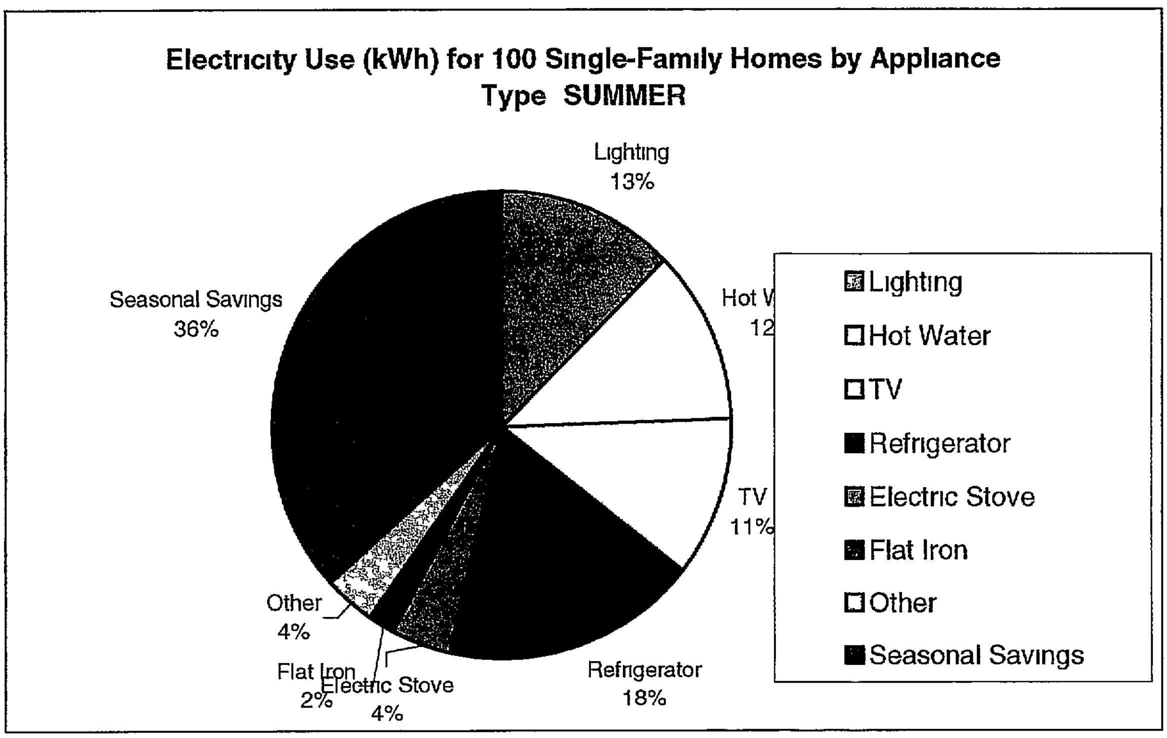
The graphs on the following four pages show the percentage of electricity which is consumed by each type of appliance in both summer and winter, by building type The values for electricity consumption were calculated using the appliance load requirement (rated wattage) and the hours of reported usage In the pie charts for summer appliance use, a category "seasonal savings" is inserted to represent the usage of electricity for space heating in the winter by building type This is done so that the usage of appliances (other than space heating) can be directly compared from winter to summer The comparison of electricity uses in the winter and summer are also shown in *Table 5*

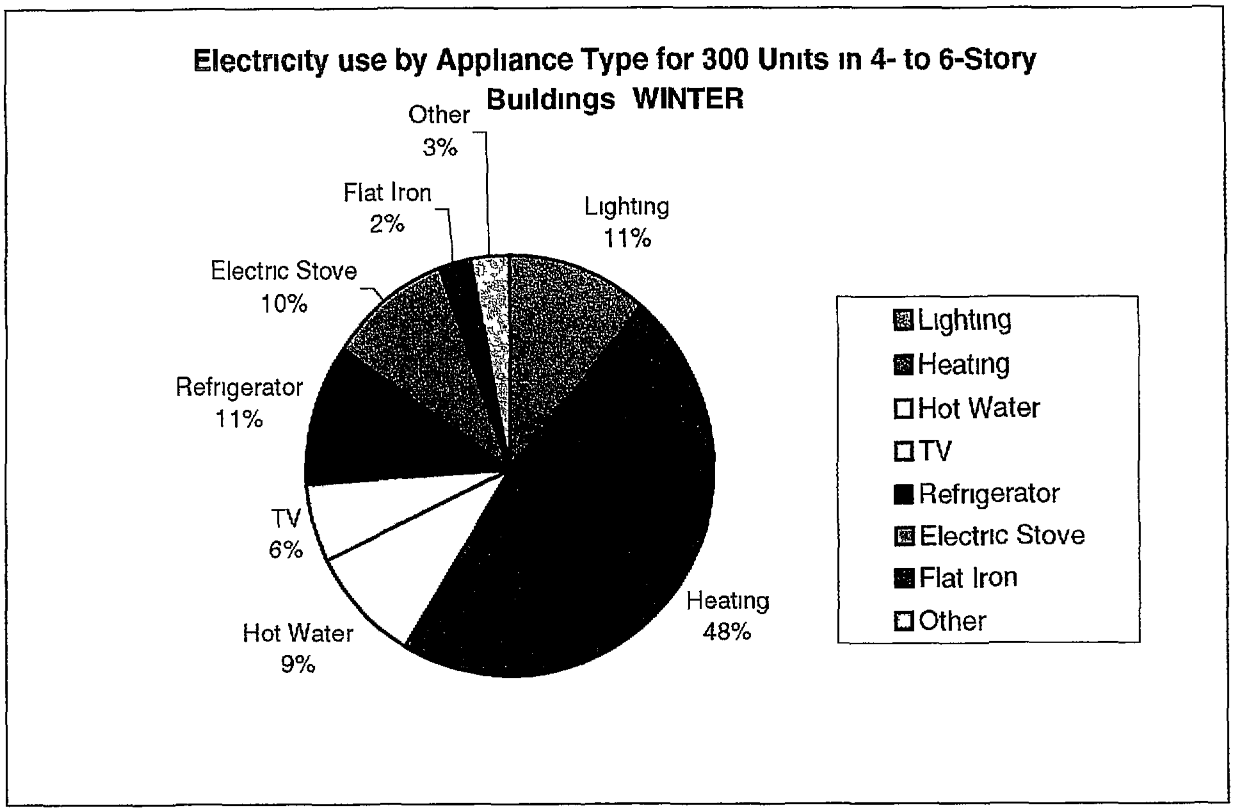
Table 5
Weighted Average Electricity Use by Appliance Type
(Total of 1000 Dwellings)
Winter vs Summer

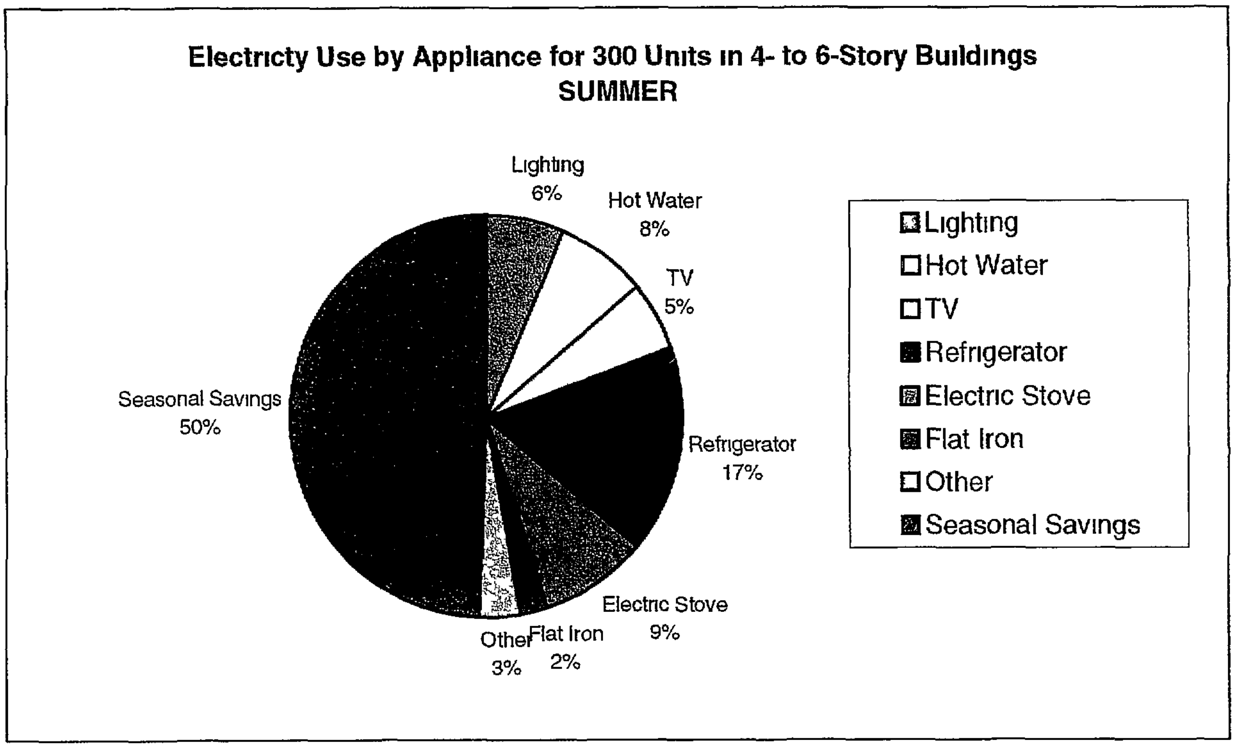
	Winter	**Summer**
Space Heating	42%	Not Applicable = Seasonal Saving
Electric Stove	13%	12%
Lighting	12%	6%
Hot Water Heating	11%	8%
Refrigeration	10%	17%
TV	7%	6%
Ironing	2%	2%
Other	3%	3%

Lighting, hot water heating, and refrigeration are the only appliances that have substantial differences between summer and winter use (subtracting out winter space-heating requirements) The differences in lighting and refrigeration can be easily explained by seasonal variation - longer daylight hours in the summer, warmer temperatures (in winter, some items are stored on outside balconies, rather than in refrigerators) The difference in hot water heating in the summer may be due to lower requirements for clothes washing (people wear fewer clothes), and to fewer hot water requirements for bathing

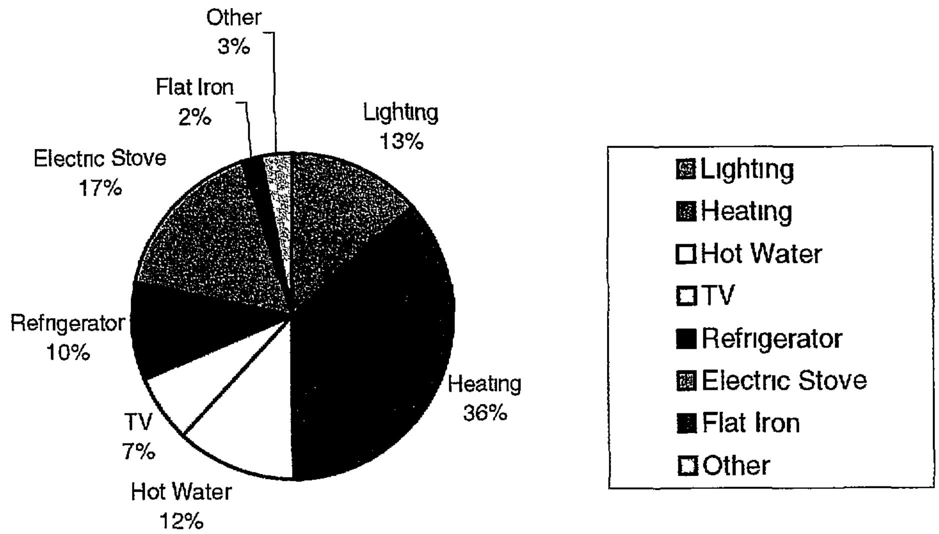

Electricity Use for 100 Single-Family Homes by Appliance Type
WINTER
Other 3%
Flat Iron 2%
Electric Stove 6%
Lighting 17%
Refrigerator 13%
TV 11%
Hot Water 11%
Heating 37%
Lighting
Heating
Hot Water
TV
Refrigerator
Electric Stove
Flat Iron
Other


Electricity Use (kWh) for 100 Single-Family Homes by Appliance Type SUMMER
Lighting 13%
Seasonal Savings 36%
TV 11%
Other 4%
Flat Iron 2%
Electric Stove 4%
Refrigerator 18%
Lighting
Hot Water
TV
Refrigerator
Electric Stove
Flat Iron
Other
Seasonal Savings

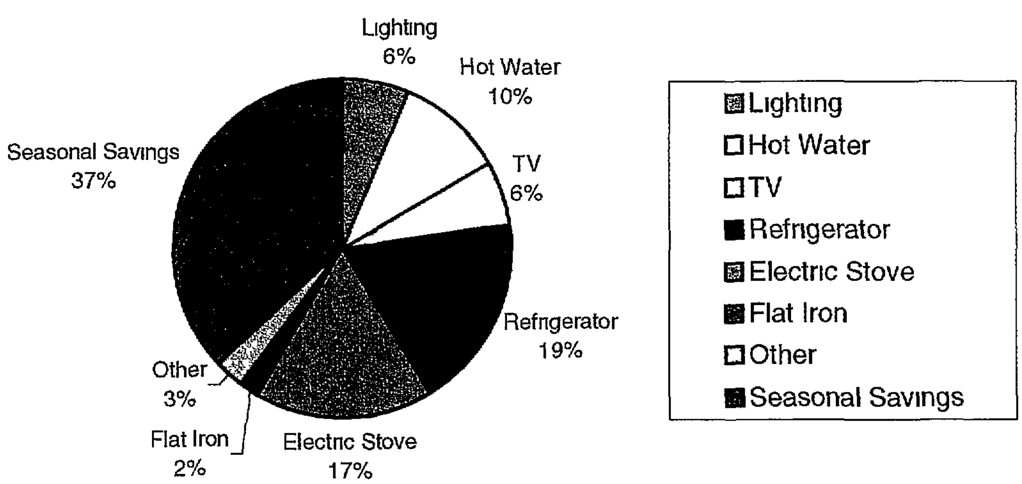

Electricity use by Appliance Type for 300 Units in 4- to 6-Story Buildings WINTER
Other 3%
Flat Iron 2%
Lighting 11%
Electric Stove 10%
Refrigerator 11%
TV 6%
Hot Water 9%
Heating 48%
Lighting
Heating
Hot Water
TV
Refrigerator
Electric Stove
Flat Iron
Other

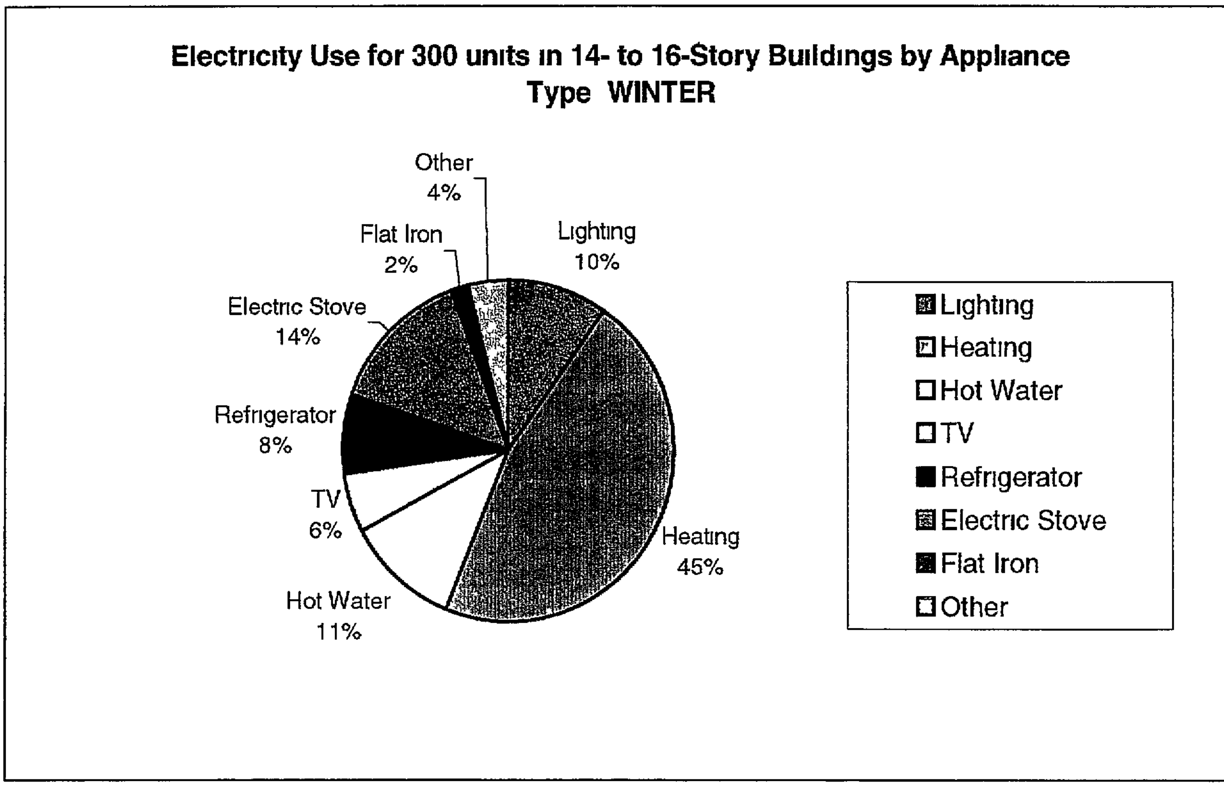

Electricty Use by Appliance for 300 Units in 4- to 6-Story Buildings SUMMER
Lighting 6%
Hot Water 8%
TV 5%
Seasonal Savings 50%
Refrigerator 17%
Electric Stove 9%
Other 3%
Flat Iron 2%
Lighting
Hot Water
TV
Refrigerator
Electric Stove
Flat Iron
Other
Seasonal Savings

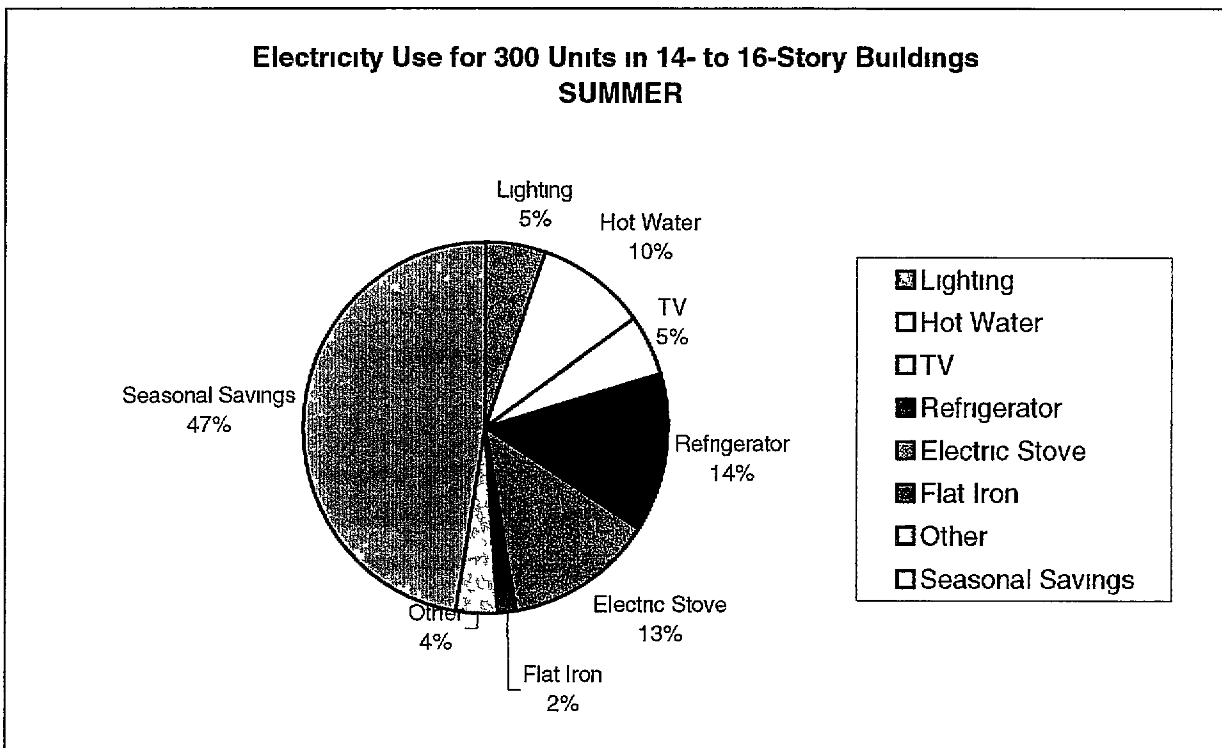
Electricity Use for 300 Units in 9- to 12-Story Buildings by Appliance Type WINTER



Electricity Use for 300 Units in 9- to 12-Story Buildings by Appliance Type SUMMER




Electricity Use for 300 units in 14- to 16-Story Buildings by Appliance Type WINTER
Other
4%
Flat Iron
2%
Lighting
10%
Electric Stove
14%
Refrigerator
8%
TV
6%
Hot Water
11%
Heating
45%
Lighting
Heating
Hot Water
TV
Refrigerator
Electric Stove
Flat Iron
Other


Electricity Use for 300 Units in 14- to 16-Story Buildings SUMMER
Lighting
5%
Hot Water
10%
TV
5%
Seasonal Savings
47%
Refrigerator
14%
Electric Stove
13%
Other
4%
Flat Iron
2%
Lighting
Hot Water
TV
Refrigerator
Electric Stove
Flat Iron
Other
Seasonal Savings

10

Table 6 summarizes the appliance use data from the surveys for those appliances which have the highest electricity consumption

Table 6
Appliance Electricity Usage Characteristics

Type of Appliance[1]	Typical Rated Wattage (kW) [2]	Average Hours of Use Per Day	Typical kWh Consumption Per Day	Penetration Rate
Lighting	0 28	5	1 4	100%
Space Heating [3]	2 8	3	8 4	60%
Hot Water Heat	1 0	1	1 0	94%
Television	0 10	6	0 6	96%
Refrigerator[4]	0 15	24	3 6	88%
Electric Stove	1 0	2	2 0	85%

Notes
1 Only lighting has more than one appliance per apartment with varying sizes e g , 40watts and 60 watts All appliances, other than lighting are one per apartment where their usage is reported
2 Penetration rate is defined as the percentage of residents which own a given appliance
3 Space heating and air conditioner use are seasonal
4 The compressor of the refrigerator cycles throughout the day depending upon the ambient temperature and the number of times the refrigerator is opened during the day The detailed estimate of the average number of hours per day was beyond the scope of the survey

Appliance Replacement

Residents were asked which appliances they would replace if they had any extra money The most common responses (in order) were TV (30%), refrigerator (20%), washing machine (20%) and other (vacuum cleaner, audio center, etc - total 30%) Approximately 20% of residents did not reply to this question, since they did not anticipate having any extra money for the purchase of new appliances These replacement expectations may have some impact on the selection of potential appliance standards and labeling programs

6 RESPONSE TO TOU INCENTIVES

One important DSM strategy which is being discussed locally is that of installing time-of-use meters in residences and offering a preferential rate for shifting electricity usage to non-peak times In the survey, residents were asked if they would shift their use of electricity if given a preferential tariff, and what level of tariff reduction would induce them to shift Residents were given a choice of preferential tariff equal to 25, 50, and 75 percent of current tariffs In all categories, 75% - 85% of the residents said that they would consider shifting their electricity usage to night-time (2300 to 700 hours) if given a preferential tariff Their responses to the level of inducement necessary to influence such a shift is shown in *Table 7*

Table 7
Willingness to Shift Electricity Usage to Night-Time (2300-700 hours)
Based on Tariff Level (Percentage of Day-Time Tariff)

	25 Percent	**50 Percent**	**75 Percent**
Single-Family	18%	8%	74%
4-6 Story	45%	38%	17%
9-12 Story	36%	45%	20%
14-16 Story	45%	43%	12%

Residents were also asked which usages they would be willing to shift to non-peak times Most often mentioned were bathing, clothes washing, ironing, and cooking Bathing and clothes washing would affect the electricity used in water heating As we saw in Section 5 of this Appendix, these are not the highest electricity usages as determined by the survey Together, they account for only 22% (summer) to 26% (winter) of residential electricity use Ironing only consumed 2% of electricity use Furthermore, not all of the usage can be shifted to non-peak hours The uses that have the highest electricity consumption, i e refrigeration and space heating, are the least amenable to shifting their time of use

7 ELECTRICITY USE FOR HEATING

Space heating is a significant factor in winter electricity consumption All categories of buildings reported higher electricity usage in the winter than summer The following table (Table 8) reports the average electricity use in winter, summer and the difference, which is attributable mainly to space heating requirements

Table 8
Winter vs Summer Electricity Requirements

	Single- Family[1]	4-6 Stories	9-12 Stories	14-16 Stories
Summer Total Consumption (kWh)	733	1663	1954	2192
Winter Total Consumption (kWh)	1157	3286	3141	4176
Difference in Summer vs Winter	424	1623	1187	1984
Heating Consumption (kWh)	419	1567	1139	1937
% Difference Due to Heating	99%	97%	96%	98%

NOTE

1 The single-family-homes category included 100 surveys only, while the other building categories are for 300 surveys in each category The figures reported are average for each category

As can be seen from the table above, nearly all of the difference in electricity use in winter vs summer is due to the use of electric space heaters It is also important to note that an average of only 60% of residents in the survey reported using electric space heaters If this is broken down by building type, the percentage varies considerably

Building Type	% Reporting Use of Space Heaters	Average Reported Winter Temperature Inside
Single-Family	23%	16 24
4-6 Story	37%	16 16
9-12 Story	65%	15 56
14-16 Story	85%	14 78

The residents were also asked whether they were connected to the district heating or natural gas distribution systems, and whether they were currently (or in the case of district heating, in the winter 1997-98) being supplied with either district heat or natural gas *Table 9* shows the responses to these questions Finally, residents were also asked whether they used any renewable sources of energy for heating or other uses Of the 1000 apartments surveyed, none reported using any renewable sources of energy

Table 9
Other Potential Heat Sources

	Single-Family	4-6 Stories	9-12 Stories	14 16 Stories
Connections to District Heating				
Number	4	259	290	300
Percentage	4%	86%	96%	100%
Supplied with Heat in Winter 1998				
Number	0	135	103	56
Percentage	0	45%	34%	19%
If Supplied, Also Used Additional Heat (%)	N/A	84%	93%	36%
Connection to Natural Gas Distribution				
Number	85	269	265	132
Percentage	85%	90%	88%	44%

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Percentage Supplied with Natural Gas	2%	0%	<1%	0%

In multi-family residential buildings, a vast majority of the residents were connected to the city's district heating systems Only about one-third of residents who were on the district heating system were supplied with some district heat during the winter of 1998 In a vast majority of cases in the 4- to 6- and the 9 to 12-story buildings, the heat was insufficient to meet their total heating requirements In the 14- to 16-story buildings, the heat provided by the district heating system was adequate for about two-thirds of the residents, i e only 36% of the residents required supplemental heating In single-family homes, only a very small percentage were connected to the city's district heating network

Nearly 90% of the residents were connected to the natural gas distribution system, but almost none were receiving natural gas supplies If natural gas or district heating could replace electricity as the dominant source of heat, there would be a significant impact on the amount of electricity required in the winter As the survey data shows, the use of other sources to provide heat could reduce the winter load to more nearly match the summer load

It is also relevant to note that indoor temperatures are not necessarily comfortable, i e residents might prefer a more moderate temperature Residents were asked the average temperature inside their apartments in winter and in summer The average temperature in the winter time was reported to be about 14-15 degrees C, while in summer time the average temperature was reported to be 26-27 degrees C A more comfortable temperature would be 22 degrees C in both summer and winter In order to achieve this level of comfort, more electricity would be needed for heating in the winter and cooling in the summer Only a very small number of residents surveyed (less than 1%) currently had air conditioning As the Armenian economy improves, it is anticipated that more people will purchase air conditioners to maintain a higher comfort level

8 COMMON SPACES

A significant societal problem in all countries of the former Soviet Union, including Armenia, is the use and maintenance of common areas in multi-story residential units This would include elements such as stairways, elevators, lighting in the common areas, and pumps for water distribution Historically, these areas were maintained by a city maintenance department, which also budgeted for their upkeep and expenses Now that the apartments have been privatized, residents are not certain of who is responsible for the upkeep of these areas and for paying the energy use charges attributable to these areas

In the survey, residents were asked who was responsible for maintaining and paying the electricity use for these areas Overwhelmingly, residents said that apartment owners were responsible for paying for electricity use resulting from lighting needs for stairways and hallways In fact, this cost is usually split by those residents who can afford to pay, and are willing to bear this expense Many hallways are simply not lit at night, due to residents' unwillingness to pay for this expense There seems to be no systematic sharing of cost or responsibility for paying for lighting the common areas

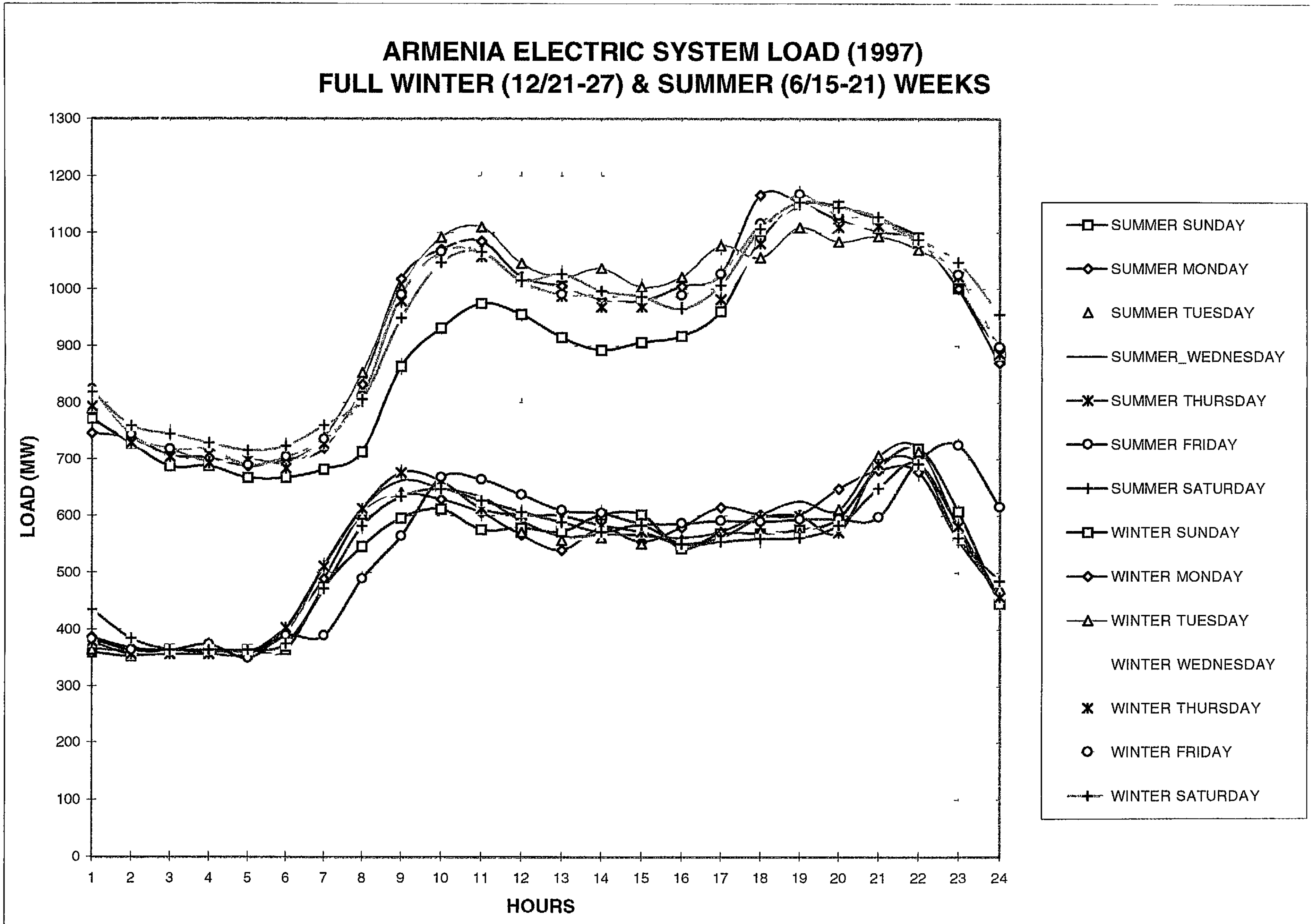
Residents were also asked about payments for electricity for running the elevator and for water pumping No residents reported paying any amount for either elevator or water distribution This electricity usage should be part of the building operating expense, however, it appears at this time that residents are not responsible for this payment It is probable that the expense for this electricity is billed to each of the districts within the city of Yerevan Because residents are not paying for the use or maintenance of elevators or water pumps, these services are frequently out of order, and no one takes responsibility for repairing them If residents took responsibility for these services, it is more likely that they would be continuously operating (assuming they could afford the cost of maintenance and operation)

9 MAJOR CONCLUSIONS

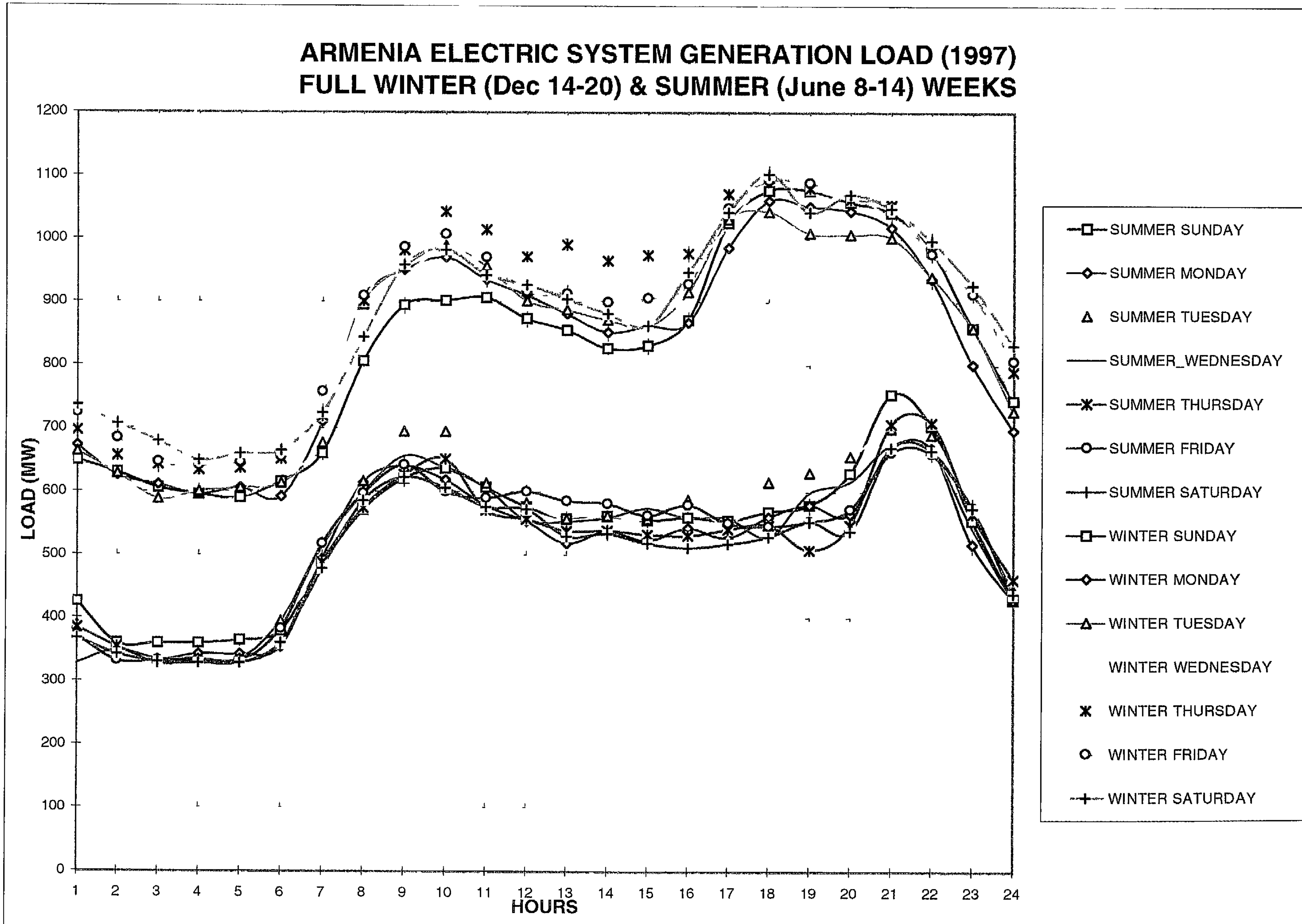
The major conclusions of the residential end-use survey (based on preliminary analysis only), and the directions they provide for energy efficiency implementation strategies, including through DSM, could be summarized as follows

- Awareness about electricity use, and its associated costs, exists among the customers, in general,
- Space heating, water heating, lighting, cooking and refrigeration have the major share of electricity consumption, and should be the focus of efficiency improvements,
- Time of use (Day/Night) tariff is potentially a viable option because over 75% responses indicated that they would be willing to opt for the preferential tariff if this system is introduced This is also due to the fact that electricity costs have a substantial share (15%-25%) of their family incomes, and
- Potential information DSM programs and standards and labeling policies could be prioritized according to the appliance replacement projections determined through these surveys

APPENDIX - II
ARMENIA SYSTEM GENERATION LOADS



arload97 xls


ARMENIA ELECTRIC SYSTEM GENERATION LOAD (1997)
FULL WINTER (Dec 14-20) & SUMMER (June 8-14) WEEKS
LOAD (MW)
0
100
200
300
400
500
600
700
800
900
1000
1100
1200
HOURS
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
SUMMER SUNDAY
SUMMER MONDAY
SUMMER TUESDAY
SUMMER_WEDNESDAY
SUMMER THURSDAY
SUMMER FRIDAY
SUMMER SATURDAY
WINTER SUNDAY
WINTER MONDAY
WINTER TUESDAY
WINTER WEDNESDAY
WINTER THURSDAY
WINTER FRIDAY
WINTER SATURDAY

APPENDIX - III
RESIDENTIAL END-USE APPLIANCE SURVEY

RESIDENTIAL END-USE APPLIANCE SURVEY

The following appliance information was gathered from 2 stores in Yerevan that carried a wide variety of residential appliances Survey was conducted the first week in August, 1998

Overview is that all products are imported from Europe, comparable in price to the US, and are mainly electric with the exception of some kitchen stoves that have both electric and gas burners In response to question about customers concern with energy efficiency/consumption vs Price of product, both store managers without hesitation claimed consumers are only concerned with initial purchase price, energy efficiency of appliances almost never is a buying decision

Shop Name	Location
Aray Shop	Komitas Street
Electrolux	Sayat-Nova

APPLIANCE TYPE	BRAND NAME	TECHNICAL INFO		PRICE
Stoves				
Electric only	Sanyo and Hitachi	1 3-2 kw		$350-600 US
Gas and Electric				$982
(These stoves will use both propane and natural gas by adjusting the size of the gas outlet valve)				
Air conditioners				
	MEC	12,000 BTU/hour 3 5 kw		$660
	MEC	18,000 BTU/hour 5 2 kw		$920
	National	2 08 kw normal use-2 5 kw maximum		
Space heater only				
		Oil filled floor standing type-2 kw		
Space heaters/AC combination				
	Hitachi	12,120 BTU/h	3 55 kw	$1,060
		15,360 BTU/h	4 5 kw	
Refrigerators				
	Sanyo	650 liters	175 watt	$1,468
	Sanyo	415 liters	175 watt	700
	Aftron	? liters	175 watt	540
	Indesit	? liters	110 watt	400-600
	Ariston			600-1,000
Washers				
	Hitachi	1 30-1 35 kw		$ 280
	Sharp			220
	Hitachi			490

APPLIANCE TYPE	BRAND NAME	TECHNICAL INFO	PRICE
Dryer			
	Bosch	2 2 kw 130 watts	$620-1,100
Vacuum cleaners			
	Bosch	1 1-1 3 kw	$100-150
	Hitachi	1 2 kw	100
	Rowenta	1 1-1 2 kw	130-160
	National	1 2 kw	240
	Electrolux	1 1 kw	180
Micro waves			
	Teba		$160
	Bosch		500
Water Heaters			
	Ariston	1 2 kw 80 liters	$130
	Ariston	2 0 kw 500 liters	1,600
Light bulbs			
Philips florescent screw in type available in market place			
	Philips	60 watt	$10

APPENDIX - IV
DRAFT ENERGY EFFICIENCY LAW OF ARMENIA

updated

Draft
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ENERGY EFFICIENCY
LAW
OF THE REPUBLIC OF ARMENIA

This Law defines the state policy making principals with regard to the energy efficiency sphere of the Republic of Armenia and state management system for their implementation

SECTION I

GENERAL PROVISIONS

Article 1 Main Definitions

The main definitions used in the Law

Energy Efficiency - a system of legal, organizational, scientific, production, technical and economical mechanisms which is directed to the efficient utilization of energy resources,

Energy Efficiency Sphere - a system of activities carried out in all spheres of economy, when implementation of legal, organizational, scientific, production technical and economical mechnaisms leads to the energy efficiency,

Energy Resources - energy carrier currently under usage, or to be used in future

Efficient utilization (acquisition) of Energy Resources - in the contemporary stage of technology development economically justified utilization (acquisition) of energy carrier provided the satisfaction of environmental requirements

Energy Efficiency Indicator - absolute or relative value of utilization of the energy resources for any type of product in compliance with the normative documents, as well as with the national standards

Article 2 Purposes of the Law

The purpose of this Law is to define the legal framework for implementation of state policy in the energy efficiency sphere,

Article 3 Scope of the Law

This Law shall regulate the activities and the relationships among state bodies, legal and physical persons in the energy efficiency sphere of the Republic of Armenia

Article 4 Application Sphere of the Law

The Energy Efficiency Sphere shall be the application sphere of the Law, icluding

a Acquisition, transportation, conversion, storage and use of the energy resources,

b Recording, metrology of the energy resources and development and approval of the norms for their consumption (losses),

c State management and supervision over the energy efficiency,

d Development, production, import and use of energy efficient machinery and equipment, as well as light constructions and insulation materials which produce, transport, convert, store and use the energy resources

e Selection, development, production and implementation of energy efficient construction and schemes of technical systems (including lighting, heating, air-conditioning, water supply and water removal complexes), which use energy resources selection and use of efficient types of the energy resources to be used in that systems,

f Development, design, production, import and use of measurement equipment, technical means regulating the control and consumption of the energy resources,

g Implementation of the organizational, production scientific-research, design expert testing, installation, calibration and repair operations for the efficient use of energy resources

Article 5 Legal Regulation of Energy Efficiency Relations in the Republic of Armenia

1 The relations with regard to the energy efficiency in the Republic of Armenia shall be regulated pursuant to the Energy Law of the Republic of Armenia, this Law and other legal statutes

2 If the provisions set forth in International Treaties of the Republic of Armenia are in conflict with the provisions prescribed in this Law, the provisions of International Treaties shall prevail

Article 6 State Policy Principles with Regard to the Energy Efficiency Sphere

The state policy principles with regard to the energy efficiency sphere are to be

a Ensuring priority of energy efficiency implementation in all spheres of economy of the Republic of Armenia,

b Superiority of the energy efficient use of energy resources over their import and export,

c Increase of the volume of more efficiency in the production balance of energy resources,

d Establishment of state management system over the efficient use of the energy resources in all sphers of economy in the Republic of Armenia,

e Promotion of the efficient use of the energy resources in the territory of the Republic of Armenia,

f Foreseeing of the specific expenses in the state budget to finance energy efficiency projects

SECTION II

STATE MANAGEMENT WITH REGARD TO THE ENERGY EFFICIENCY SPHERE

Article 7 Implementation of State Policy in the Energy Efficiency Sphere

The authorities responsible for implementation of state policy with regard to the enegy efficiency sphere shall be the Government of the Republic of Armenia and state management bodies authorized by the Government of the Republic of Armenia (hereafter Authorized Bodies)

Article 8 State Management with Regard to the Energy Efficiency

The state management with regard to the energy efficiency are to be

a Establishment of the state management system (state management and supervision bodies, complex of the normative legal statues and standards, certification procedures, technical mechanisms) to promote the efficient use of energy resources in the territory of the Republic of Armenia,

b Ensuring the energy efficiency policy objectives in the state projects to develop the spheres of economy of the Republic of Armenia, c Accounting for the energy resources produced and used according to the procedure defined by the Government of the Republic of Armenia,

d Creation of economic, legal and moral conditions to encourage energy efficiency among the state regulated entities performing in the sphere of energy efficiency, with the consideration of interests of energy resource producers, suppliers and consumers

e Ensuring state management of the energy efficiency by the application of the economic methods, and implementation of normative and technical requirements and conditions,

f Incorporating energy efficiency indicators into the state standards for constructions (residential, public and etc), facilities, equipment, materials, and transportation means according to the procedures defined by the Government of the Republic of Armenia,

g Certification of the equipment converting and consuming energy resources and their testing facilities,

h Ensuring accuracy and validity of unified metering and accounting for the energy resources

i Development and application of state standards for energy efficiency and the set of normative and technical documentation for prudent specific consumption of energy resources

Article 9 Standardization in the Efficiency Sphere

The system of normative acts, as well as national standards shall be established to define energy efficiency indices for the energy generation and convertion equipment and energy consumption production (products)

The indicators for energy efficiency of development, production, processing, conversion transportation, storage and consumption of energy resources and indicators of energy consumption for buildings' heating, illumination, ventilation and hot water supply and production process shall be incorporated in the normative-technical documentation according to the order defined by the Government of the Republic of Armenia

The standardization with regard to energy efficiency sphere shall be carried out by the Authorized Body of the Government of the Republic of Armenia

Article 10 Certification in the Energy Efficiency Sphere

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Product items and energy facilities consuming energy resources are subject to certification according to appropriate standards for energy efficiency due to the order defined by the Government of the Republic of Armenia

The list of energy facilities subject to certification shall be defined by the Government of the Republic of Armenia due to the submission by its Authorized Aody

The compliance of household appliances and other devices consuming electricity with requirements defined by normative acts and national standards, in terms of energy consumption indicators, shall be approved by marking (mark of accordance) the given devices

Article 11 Metrology in the Energy Efficiency Sphere

The authorized bodies shall carry out metrology testing to clarify the energy efficiency situation (level) at the energy facilities of the legal and physical persons

Article 12 Implementation of State Supervision in the Energy Efficiency Sphere

The state supervision over the energy efficiency sphere shall be carried out by the authorized bodies of the Government of the Republic of Armenia

The Government of the Republic of Armenia shall define the list of activities, subject to the state supervision, performed by the legal and physical persons in the energy efficiency sphere,

The forms of supervision over the energy efficiency sphere shall be as follows

a Implementation of the energy testing and examination of legal and physical persons' facilities, which are subject to control, according to the order defined by the Government of the Republic of Armenia,

b Definition of the specific consumption of energy resources in energy consuming productions (products) and testing their compliance with the normative legal acts and national standards defined by the Government of the Republic of Armenia,

c Control over the compliance with the normative technical standards of technical means and systems used for the determination of the qualitative and quantitative indices of the energy resources,

d Energy testing of the design and construction documents and construction technologies with regard to the new entities and their compliance with the normative acts, as well as national standards,

e Implementation of the energy expertise of projects and programs, directed to the development of the economy branches and testing their compliance with this Law and the other legal statues proceeded from this Law

Article 13 Accounting, Follow-up and Statistics of the Energy Resources

Energy resources and their quantity and quality, which are developed, produced, processed, converted, transported, stored and used shall be subject to account and control according to the order defined by the Government of the Republic of Armenia

The technical specifications (parameters) of the quality, consumption, accounting of the energy resources, the structure of the metering systems and the technical conditions shall be defined by the authorized bodies

Article 14 Economic Provisions for Energy Efficiency Promotion

The economic provision of energy efficiency shall be carried out by the following mechanisms

a The legal and physical persons using the energy installations with indicators exceeding the standards and norms in force and the secondary and alternative energy resources shall be given a loan, tax and customs duty privileges according to the legislation the Republic of Armenia

b The individuals and working staff, efficiently using the energy resources, shall be rewarded according to the Legislation of the Republic of Armenia

Article 15 Financing of the Energy Efficiency Undertakings

The activities in the energy efficiency sphere shall be financed from the state budget bank loans means of legal and physical persons, local and foreign investments

Scientific-research developments and activities with regard to the energy efficient modern technologies, the use of the alternative and secondary energy resources shall be financed from the state specific financial sources

Article 16 Scientific Research, Training and Education with Regard to the Energy Efficiency Sphere

To develop the complex of scientific researches and the bases for the contemporary energy efficient processes and technologies in the energy efficiency sphere, the state management authorized bodies are to

a Plan the courses on energy efficiency in the educational programs of the Armenian secondary and high technical institutions of the Republic of Armenia, as well as appropriate scientific-research activities,

b Dedicate the training courses for the engineering staff with regard to the energy efficiency principles and technique, as well as to the main provisions for the use of alternative and other energy resources c Plan the special training courses on energy efficiency for the management staff of the energy facilities with 2000 kWh thermal and/or 1000 kWh electrical installed capacity The authorized body shall grant the energy manager qualification (energy manager certificate) to those individuals who have completed these courses

Article 17 Energy Efficiency Propaganda

Propaganda of the energy efficiency state policy among the population of the Republic of Armenia shall be carried out through

a Public discussions of the energy efficiency programs, broadcasting and propaganda of the environmental, economic and social advantages of energy efficiency,

b Information about the existing energy efficient energy facilities and energy efficiency illustrative projects,

c The organization of the exhibitions of energy efficiency technologies, machines and energy facilities,

d The propaganda of the necessity and advantage of the efficient use of energy resource

SECTION III

INTERNATIONAL COOPERATION

Article 18 International Cooperation

The main directions for international cooperation of the Republic of Armenia in the energy efficiency sphere are the following

a Exchange of energy efficient technologies and devices,

b Compliance of the energy efficiency indicators with normative documents, as well as with national standards and mutual recognition of certification results

c Exchange of information with regard to the energy efficiency sphere,

d Participation of legal and physical persons of the Republic of Armenia in the international energy efficiency projects

APPENDIX - V
FINANCING ENERGY EFFICIENCY IN ARMENIA

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FINANCING ENERGY EFFICIENCY IN ARMENIA

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and

Gourgen Z Melikian
Energy Consultant
Toronto, Ontario, Canada

Abstract

As part of the strategy for mitigating the impact of the planned closure of the Armenian Nuclear Power Plant, Resource Management Associates has been investigating the potential for energy efficiency improvements in electrical end-uses Many potential areas in all economic sectors have been identified A major constraint in implementing energy efficiency in Armenia and in other countries of the former Soviet Union is the lack of available financing This paper looks at potential financing mechanisms for implementing energy efficiency, based on the authors experiences in Armenia Russia and other countries One such mechanism which has been used successfully in other countries is the establishment of energy service companies (ESCOs) Barriers and constraints to the development of ESCOs as a viable financing mechanism are discussed Recommendations are made on actions which can be taken to increase the funding available for energy efficiency

Introduction

The countries of the former Soviet Union in general and Armenia in particular, face unprecedented challenges to revamp their energy economies Historically low energy prices created energy systems which are characterized by over-consumption and waste Centralized decision-making has contributed to a "cookie-cutter' approach to the design of energy systems The past and continuing economic impact of these inefficient energy systems has been widely observed and analyzed A general conclusion is that under-investment in energy efficiency has led to an over-investment in energy supply and a negative effect on economic growth

The problem in Armenia has been compounded by an energy supply shortage in the past several years Unreliable energy supply led to the decision by the government of Armenia to reopen the Armenian Nuclear Power Plant (ANPP) in 1996 This decision is not a popular one on the part of Armenia's neighbors or others in the world community Concerns about the safety of the nuclear reactor, and the potential for earthquake damage to the nuclear plant have led to negotiations regarding closure of ANPP The Government of Armenia has agreed to close the ANPP by the year 2004, and is considering options for replacement generation capacity which can be developed in the period 2000-2004

A proven alternative to supply side increases is to improve the end-use efficiency of consumers In the US demand-side options (increases in energy efficiency) have been found to be significantly lower in cost than supply-side options (increasing generation capacity) The cost of saved energy has averaged $400/kW as opposed to an average cost of $1,500/kW for increasing the supply of energy Energy efficiency options are also attractive in that they have positive environmental benefits reduce the need for imports, and allow the same end-use benefits (lighting, heating, etc) at lower cost A companion paper prepared by Dr Ashok Sarkar of RMA discusses further the technical options and the rationale for implementing a DSM program in Armenia

The financing requirements for implementing DSM options, while lower cost per kW, are still beyond the means of most individual consumers in Armenia This paper will discuss the some options for mobilizing scarce capital resources to energy efficiency, using examples from the authors' experience in other countries of the former Soviet Union and elsewhere Particular emphasis will be placed on financing through different ESCO approaches

What Is An ESCO?

An Energy Service Company (ESCO) in the most generic sense is a company which supplies a range of services to clients to improve their energy efficiency However, the term ESCO is widely used with varying interpretations, so it is necessary to offer a more precise definition of what services ESCOs commonly provide There are generally two types of ESCOs

Service ESCO - An organization which performs engineering and financial analyses but does not provide project financing or guarantees The types of services provided include energy audits, identification of cost-effective energy efficiency measures, equipment installation and maintenance, and monitoring of equipment operation and energy savings

Financial ESCO - An organization which provides the full range of energy services including energy auditing and financial analysis of energy efficiency measures, project financing, equipment installation and maintenance monitoring of equipment operations and energy savings, and training of facility staff A financial ESCO also provides a guarantee of energy or cost savings

In the US, and to some extent internationally, the term ESCO has come to be conventionally defined as the financial ESCO ESCOs have been used successfully in the US to provide energy efficiency project financing, largely for institutions which have difficulty financing energy projects through budgetary resources or conventional bank financing Most commonly, ESCO applications have been with schools and government buildings which are typically unable to secure energy project funding through their normal budget process The energy projects are implemented under an arrangement known as performance contracting In performance contracting, the ESCO guarantees a level of energy savings and the client makes payments to the ESCO over time on the basis of how well the project performs relative to the energy savings guarantee In the US and Europe, ESCO ownership and operation can take on several different forms including utilities equipment manufacturers financial institutions and energy/engineering consulting firms There are advantages and disadvantages to different types of ownership for both the owner and the client but in the US, ESCOs are generally privately-owned and provide similar services

The Barriers to Financial ESCOs in Armenia

With the tremendous potential for energy efficiency improvements, one might speculate that ESCOs in Armenia and other parts of the former Soviet Union would be thriving This section will discuss the barriers which face ESCO development, with a particular emphasis on Armenia Following each barrier is some discussion of the authors findings in work throughout the former Soviet Union

1 Energy Pricing - Low energy tariffs will make energy efficiency projects unattractive due to a payback period which is too long to be a good investment This is a significant problem in district heating in the residential sector, where 70% of the tariff is subsidized by the municipal government The level of the subsidy is not determined on a needs basis (income dependent), but rather is determined at the national level In Armenia, where district heating was suspended due to lack of natural gas supplies electricity has been the dominant energy source for heating purposes While electricity prices have risen substantially in recent years, the tariff is still well below the cost of service Incomes for the average person have not kept up with increasing costs resulting in non-payment problems

Rational energy pricing is one of the most difficult barriers to overcome on a societal level without serious social dislocation It is one of the most crucial barriers to overcome since unless the resource cost of energy is truly reflected in its market cost, there is no incentive for greater efficiency The true resource cost should reflect not only the operational costs, but also the ongoing maintenance, replacement and societal costs of energy (e g environmental externalities such as harmful air emissions or storage of spent nuclear fuel) If all of these costs are factored into the tariff, much of the residential sector would not be able to afford to pay for their energy use The way this situation is addressed in the US is through targetted assistance to those who truly can not pay Governments and utilities offer special assistance to vulnerable groups, and programs to improve the energy efficiency of their homes and apartments

Even under the existing pricing distortions, there are opportunities for cost-effective energy efficiency based on current prices In Armenia, a good target might be commercial buildings such as banks and retail stores In Russia the authors identified many industrial sector projects in sectors which were privatized and thriving, e g food processing In the near term, ESCOs need to identify those opportunities and demonstrate that the technologies will work to encourage replication

2 Metering - Metering for electricity and gas at the residential level is limited (for district heating metering is non-existent), but almost universal at the industrial and commercial levels If energy use is not metered, it is difficult to establish a baseline energy usage, and to measure the savings unless the project includes additional investments required to install meters This in effect drives up the cost of the project without adding to the savings Lack of metering also contributes to a general ignorance of energy cost and usage

In Armenia where without the ANPP, there is a serious energy deficit, the electric distribution utilities have instituted aggressive programs of metering and bill collection This program is based on apartment level metering in most cases In some locations there is building level metering, with one of the residents acting as the collection point If bills are not paid the entire building is cut off What appears to have happened with building level metering is that those who are able to pay pick us the cost for those who are truly unable to pay There is still a problem with supplying electricity to common areas such as stairwell lighting, elevators, etc No one in the building considers themselves as being responsible for these areas, so they are unserved in many cases (e g no light in the hallways) Armgazprom recently began resupplying natural gas to homes and installed gas meters to 50,000 residences

3 Ownership of Buildings - The ownership is very unclear for many buildings in the former Soviet Union including residential housing, schools hospitals and to some extent industrial and commercial establishments In most cases, there is a proposal or plan on the books to privatize all of these structures, but the implementation dates and consequences are not widely known and understood With the uncertainties, neither the current owners nor the potential owners want to make investments until they are certain they will be the ones to benefit For residential buildings, privatization increases the owners costs as they take on the added expense of maintenance and actual utilities consumed This is a disincentive to ownership, particularly for those on fixed incomes

As discussed above there is an unwillingness for apartment owners to take responsibility for common areas of a building Currently, these are supposed to be maintained by the municipal building authority which is part of the city government One way to address this problem might be the establishment of condominium associations to maintain the common areas under a fee basis A condominium association will raise the housing cost when incomes are already stretched and there are many other priorities

Most structures have accumulated years of deferred maintenance, and were poorly designed to begin with in terms of energy use considerations Thus, in many cases, in order to make an energy project successful, other items of maintenance need to be included For example, a weatherization project at a school might have a good payback period, but in order to sustain the project, one would need to fix the leaking roof first

Clear ownership is a prerequisite for encouraging better property maintenance, since otherwise there is no incentive In addition enforcement mechanisms such as building codes and a building inspection system could encourage better maintenance of properties The danger with more rigorous enforcement mechanisms is that this is the old way of doing business in the former Soviet system Enforcement led to opportunities for graft and corruption as a way to augment low salaries of enforcement officials

5 Local Materials and Labor - Energy efficient materials, equipment and skilled labor are often not readily available on the local market The equipment which is available is generally imported and expensive relative to the domestic alternatives While the labor pool is highly skilled in technical terms, energy efficiency has not been a part of this training Local labor also lacks marketing, management and skills necessary to run a successful business

Major involvement of local resources and skills played a crucial role in the success of RMA ESCO development projects in Armenia Latvia and Russia Training in project management, economics and financial analysis was provided to enhance local technical skills In Armenia, initial ongoing project management assistance was provided during the installation period Gradually, more of the oversight was being provided locally as the skills of the personnel developed In the latest phase, all of the local installation will be overseen and managed by a local ESCO This ESCO will also provide training to others in project management costing and bidding Use of local materials will enhance the sustainability as well

One way to overcome the lack of necessary skills is to involve an experienced corporate partner in the formation of an ESCO particularly if the ESCO is to provide financing The corporate partner provides the required training and oversight in the early years, and develops the local capability to operate the business in the longer term This approach is being tried by major companies (Compagnie Generale de Chauffe Honeywell Landis and Staeffa) involved in energy efficiency projects in Eastern Europe

6 Lack of Information - There is in general a lack of awareness of energy usage and the economic and financial cost of overuse Historically under-priced and undervalued energy has led to high energy intensity in all sectors There is a growing awareness of the value of energy supplies in areas which are experiencing energy shortages, and in those sectors where the cost is approaching market levels

Sharing of information is an important factor in developing a market for energy efficiency technology and services In Armenia, the local AEE Chapter facilitates the dissemination of information on energy alternatives and isa focal point for information on technology policy discussion and new developments The Chapter is also used as a forum for spreading results of energy efficiency programs and to encourage the adoption of more efficient technologies and practices

7 Uncertain Political Economic and Business Environments - All of the countries of the former Soviet Union have experienced serious economic dislocation as they make the transition to a more market-oriented economy The economic conditions are unstable and pricing distortions common Politicians struggle to make market-oriented changes while maintaining a safety net for the general population The rules of business conduct are in many cases not transparent Bribery of public officials and arbitrary application of penalties for violation of laws has unfortunately become common This situation makes it difficult, if not impossible to conduct business in a predictable manner Without major reform in these aspects it will be difficult to attract any but the most risk prone investors to Armenia and other countries of the former Soviet Union

8 Unstable Energy Supplies - Some countries are experiencing disruptions in energy supply due to non-payment for energy imports or political turmoil, e g Ukraine and Armenia The energy situation in Armenia and neighboring Georgia, as well as some regions of Russia, has been unpredictable for several years When the supply of energy is uncertain, there is no basis for establishing baseline energy use or for implementing energy improvements which are guaranteed by energy savings On the other hand where there is uncertain energy supply, there is a greater interest in energy efficiency which utilizes scarce

resources more appropriately

Cost-effective opportunities exist in developing renewable and alternative energy supply systems For example, the potential for using geothermal heat pumps in Armenia for meeting the heating and cooling loads in residential buildings is quite high Solar, wind, biomass and geothermal sources may be more cost-effective than rehabilitating existing energy systems US companies have a lot to offer in this area, in joint partnerships with companies in the FSU

9 Financing - The lack of investment capital is a widely cited barrier to investments in energy efficiency Interest rates in these countries are typically very high (15-30%) and commercial financing is available only for short term projects of less than one year (sometimes months) Energy efficiency projects are not economic under these conditions Competing demands for capital mean that only urgent-needed projects will receive priority funding

Successful energy efficiency projects will be those where there is an ongoing, measurable financial incentive for energy efficiency This may seem to the reader to be an obvious statement, one which should not need to be said However, initially, national governments and targetted development assistance can play a crucial role in overcoming some of the barriers which are discussed here Small-scale demonstration projects can provide successful examples of low-cost energy improvements which have short payback periods USAID has funded small and large-scale demonstration programs, such as provided energy efficient and environmental control technologies to utilities in Russia Successful demonstration programs show that specific technologies work, and can lead the way to replication which is funded internally In order for this strategy to be successful, dissemination of results and lessons learned is a crucial element of assistance

ESCO Financing Models

Private Sector Models

In the US market, the majority of energy efficiency projects implemented by ESCOs are financed using private sector models for financing and implementation In some cases the market was pushed through government incentives or regulation The ESCO itself can be several different types of firms (utility, equipment manufacturer financial institution A&E company or specialized firm) The common characteristic is that they all have private sector ownership which operate in a stable and predictable business environment In well-developed market economies the barriers facing each type of firm will be the same In the private sector the types of financing mechanisms that are used to implement energy efficiency projects include

- Client Self-financing - using internal funding sources to implement projects
- Client Debt Financing - Borrowing the money to implement energy efficiency
- Leasing - Ownership of the equipment generally stays with the equipment provider for some period of time with an option to purchase at the end of the agreed lease period
- Third-party financing with performance guarantees - ESCO financing or bank financing which are paid back over some period and tied to the energy savings

Because of the barriers discussed in the previous section, a solely private sector model faces unsurmountable constraints in the short-run in Armenia and other countries in transition A more realistic approach is one which combines public sector ownership with private sector ownership, or a public sector program with eventual privatization These models are discussed below

Public Private Partnership

In countries that are transitional and the government plays a more dominant role in the market, such as in the former Soviet Union, a mixed public/private effort to mobilize capital for energy efficiency may be more successful in overcoming the barriers Another way of characterizing barriers is to say that they are risks to the investor/financier The incentive for government involvement in encouraging energy efficiency is that it is a lower cost alternative to increasing supply Government support will be crucial to reduce the risks which are unacceptable to the private investor Due to existing market distortions, private investment in energy efficiency makes sense in only very limited circumstances

One method which is being used to overcome the risk of financing is to require sovereign guarantees to international financing institutions, which lowers the interest rate because of lower project risks For example, the World Bank and EBRD are the only financing organizations providing large-scale funding for energy system improvements in Russia The World Bank will provide funding only under the condition of a sovereign guarantee Russia has taken out loans for over $360 million for district heating system improvements to date, and is developing another $300 million loan EBRD is looking at a mechanism which would provide funding for energy improvements with a regional and municipal guarantee, but without a sovereign guarantee

Another mechanism by which funding is being provided for energy efficiency projects is through multi-project facilities to large foreign ESCOs In these projects, the multilateral development bank takes both a debt and equity position in the ESCO, which spreads out the project risk between the corporate ESCO and the bank Recently, EBRD approved loans to two ESCOs which will be operating in Russia (Honeywell and Landis and Staeffa) Other such loans are being considered for Russia and other countries of the FSU

A third model which involves the public sector in accepting project risks is where the government (national, regional or local) becomes a partner in a company which is established to undertake energy efficiency projects This model is being used in Russia in the Nizhny Novgorod region Here, the ESCO partners are the regional government a foreign corporate partner and the bank All three have an equity stake in the company and an active role in overseeing its operation The regional government benefits through lower expenditures for subsidy payments in the residential and municipal sectors

Public Sector Model

In Ukraine, the government is establishing an ESCO to identify and implement industrial sector energy efficiency projects The ESCO financing is being guaranteed by the national government to EBRD In Ukraine the project risk is too great to attract private or public/private financing without a sovereign guarantee The ESCO which is established is supposed to be privatized within a two year period after receiving training and assistance from a EU technical consultant However it is too early to tell whether this will be successfully completed within the two-year timeframe

Conclusion

Consumers must be aware of energy supply and demand alternatives and relative costs in order to make informed decisions including decisions about energy efficiency In order for an ESCO market to develop, energy prices must be high enough for investment in energy efficiency to be profitable During this transition period to a market economy there are many distortions in the energy market Instead of subsidizing inefficient energy use, the governments (federal, regional and local) would be better off raising energy prices and only subsidizing energy for those who truly can not afford market prices The higher energy costs would encourage people to invest in energy efficiency, and make ESCOs sustainable and profitable In the short run, it may be necessary for the public sector to take an active role in demonstrating the effectiveness of energy efficiency investments

APPENDIX - VI
LIST OF INFORMATION SOURCES

INFORMATION SOURCES

Meetings and Discussions

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Armenian Chapter of the Association of Energy Engineers
Dr Zohrab Melikyan, President

Yerevan Computer Institute
Sargis Sargisian, Director
Gagik Hovhannisyan, Deputy Director

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Gary Ockwell, Business Unit Manager
Tak Ozsan, Systems Engineer

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