FINAL REPORT ON DEMAND-SIDE MANAGEMENT PROJECT

This report describes the Demand-Side Management (DSM) work completed by Hagler Bailly under USAID Contract No. LAG-I-00-98-00005-00, Task Order No. 9, Subtask C, and includes recommendations for future activities in this area.

BACKGROUND

The current situation in the Armenian energy sector is similar to most of the other countries of the former Soviet Union. With the exception of several small hydropower facilities, the entire power sector is currently owned and controlled by the government.

The physical plant infrastructure of the energy supply and distribution systems have deteriorated or collapsed because of the lack of maintenance and capital improvements. The electric power system is still operating; however, the natural gas system and district heating systems have both deteriorated considerably. Only recently has work begun on the natural gas distribution system to partially restore it for use by consumers.

ELECTRICITY SECTOR

The electricity sector has experienced a deterioration in its generating facilities resulting in the loss of efficiencies. Additionally, fuel sources have been cut-off from some suppliers due to nonpayment. Output from the hydro facilities has dropped due to the drawdown of water from the system, particularly Lake Sevan, during the time when the nuclear facility was non-operational. Operation of the system (i.e., dispatching of generation units) has not been optimized due to a number of constraints, including the lack of accurate metering and data acquisition systems. The transmission and distribution systems are in poor shape, due to the lack of maintenance and inadequate capital expenditures. Customer metering, billing and collections are still burdened by inefficient business processes, poor equipment and inadequate financial controls. Losses, both technical and commercial, are much too high, reaching over 50% in some areas.

NATURAL GAS SECTOR

The natural gas supplies to most of Armenia were cut by Azerbaijan following the collapse of the Soviet Union. Except for the supplies to some of the thermal generating units, only recently has the natural gas supply become available to the population in the larger cities. Unfortunately, the pipelines were not maintained in the interim period (e.g., cathodic protection was interrupted); thus, to deliver new supplies to consumers requires expenditures for rehabilitation and construction of new pipelines. Although this is now being done, it will likely be years (at least three) before natural gas is available on a widespread basis.

DISTRICT HEATING

Nearly all of the district heating systems in the country are not operational and those that are operating are hugely inefficient. Estimates of the delivered efficiency of the district heating systems are as low as 20%. When the fuel supplies were curtailed, the district heating systems ceased to operate and no plans for maintaining them were adopted. Most have deteriorated to the point of being unusable even if new natural gas supplies were available. As a result, most consumers now use electric space heaters, propane, kerosene and/or wood-burning stoves to provide heat and cooking.

THE NEED FOR ENERGY EFFICIENCY

At present, Armenia is fortunate to have adequate generation capacity and reforms in place that permit reliable electricity supply for the populace as well as opportunities (albeit limited) for electricity export. However, due to the lack of investment and operating practices, the power system is in a fragile state and in the mid- to longer-term, the reliability of supply can by no means be assured. Further, with the Government of Armenia’s commitment to the international community to shut down the Armenian Nuclear Power Station (ANPP) by year-end 2004, the Government is faced with an urgent need to comprehensively review the resource options available to it to meet the energy requirements of the economy. As part of this review, it is very important that energy efficiency be closely examined as it can offer one of the best means to cost-effectively meet these requirements. Relative to other resources, it also may offer other benefits such as: promotion of local industries and job creation; import substitution; and environmental benefits.

Relative to other countries of the Newly Independent States, Armenia is also better suited for the promotion of energy efficiency because the state of commercialization in the power sector is such that most consumers pay in full for the energy services they use. Recent collection figures are around 70% for the power sector, most of which is in cash. This level of commercialization has two impacts. First, the power system has already experienced substantial decreases in demand due to the conservation effect of consumers paying for the energy they use. Hagler Bailly has noted reductions in average electricity use as high as 60% once collection improvement strategies are put in place. Second, with consumers paying for the energy they use, consumers can benefit from the economic savings that result from energy efficiency. Obviously, if consumers are not paying for their energy use, then there is no economic incentive for them to implement efficiency measures. Also, Armenia is better suited to promote energy efficiency in that it has a regulatory framework in place. Although the Energy Regulatory Commission has not addressed energy efficiency as a regulatory matter, the existence of the Commission provides an opportunity for the agency to serve as a focal point for helping to promote energy efficiency through such means as standards of performance for the utilities, consumer information/education and/or tariff design.

DEMAND-SIDE MANAGEMENT ACTIVITIES

As mentioned above, there are widespread inefficiencies and losses at all levels of the power system. Other projects undertaken by Hagler Bailly address the supply-side of the electrical supply system while the purpose of this work was to address the demand-side. Additionally, the USAID-sponsored Armenia Power Sector Metering Improvement Program has components that address the supply-side, including accurate metering of the transmission and distribution systems.

One subtask of the Armenia Power Sector Metering Improvement Program that has provided valuable input into this subtask is the nighttime tariff pilot project. Load profile data and customer load profile data obtained from that subtask was used to enhance the demand-side management work. Load profile data is very useful in designing efficiency improvement programs, especially when capacity impacts are a primary objective.

DATA ENHANCEMENT

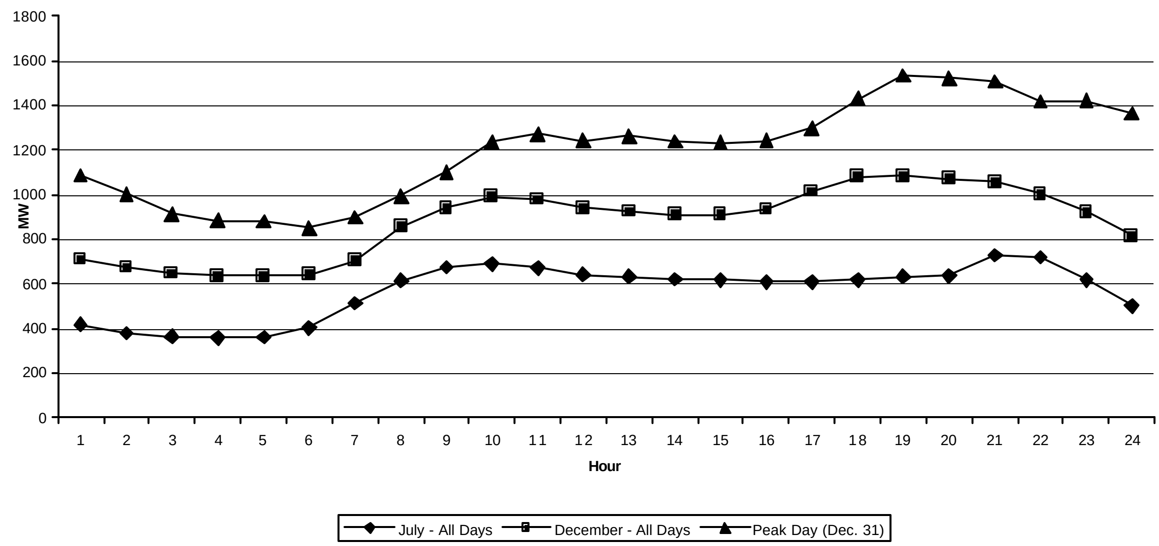
Most energy efficiency experts agree that at the level of the end-user, much of the energy inefficiency is due to the age of the appliances and equipment. Old technologies are prevalent, but accurate information about them is lacking. In order to develop a demand-side program, it is necessary to have reasonably accurate information on fuel use, equipment efficiencies and environmental impacts.

To help design both a screening model and recommended financing mechanism, demand-side data was enhanced relative to the previous work done by Hagler Bailly and other contractors for USAID in Armenia. Much of the enhancement was in the area of technologies, their costs and improvements in efficiency levels. Additionally, to estimate the impact on the environment from energy efficiency, data on emissions from thermal generating facilities was updated to reflect the current operating characteristics of the plants.

Numerous meetings were held with government agencies, such as the Ministry of Energy, the Energy Research Institute, and the Energy Regulatory Commission in order to enhance the data. Other information was acquired from both the electric and gas distribution companies as well as from the universities. Additionally, energy and environmental experts, such as members of the local chapter of the Association of Energy Engineers, provided some of the information. The data collected included the costs of equipment, operating characteristics of the appliances and equipment, and emissions from various generation technologies. This data was incorporated into the screening model described in the Hagler Bailly report *Demand-Side Management Screening Model for Armenia* (March 2000).

As mentioned, one of the areas of data collection focused on load information. Examples of the system load profiles for Armenia are shown in the first graph. While the overall magnitude of the system load varied, the analysis showed that the normalized load shape did not vary with season and day of the week. The winter loads are considerably higher than the summer loads, but the daily load profile is nearly identical. Further, the load shape is very much driven by residential consumer demands. The lack of significant industrial load in Armenia is obvious from the load profile and poor system load factor.

Exhibit 1
System Loads for 1997

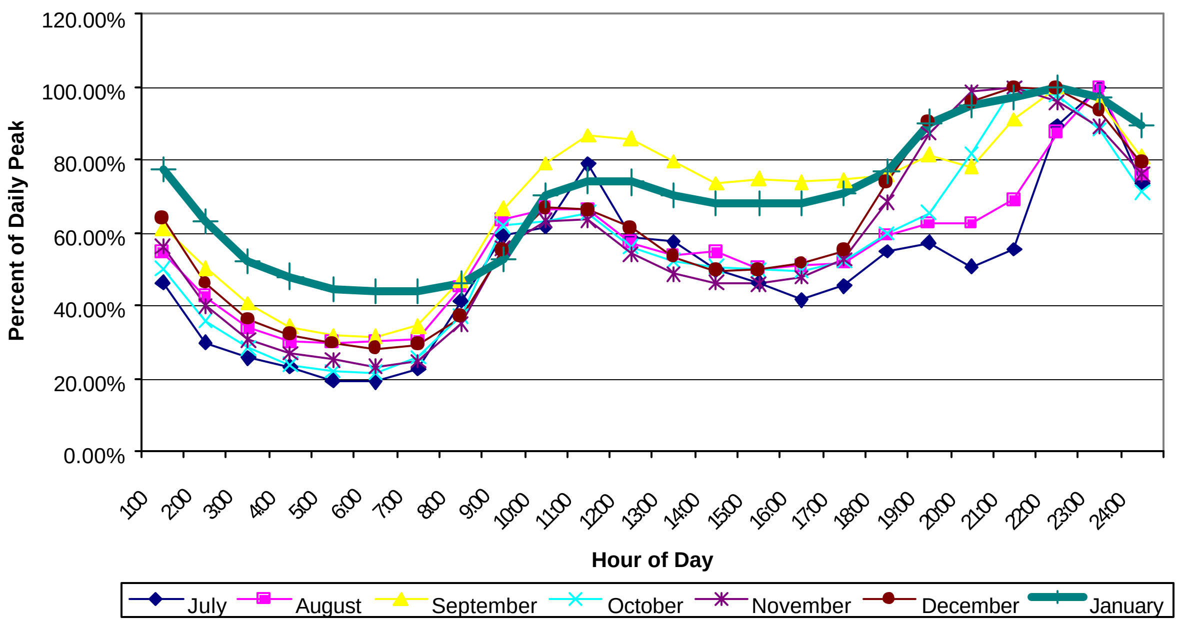


Source: Ministry of Energy; Hagler Bailly

The second graph shows the load shapes for a sample of apartments in Yerevan.[1] Again, what is noticeable about these shapes is their lack of seasonal diversity. The pattern of usage is the same throughout the year, although the level of usage differs seasonally with the winter season being much higher due to the use of electric resistance heating.

[1] This information was collected using the load measuring equipment provided under the Armenia Power Sector Metering Improvement Program.

Exhibit 2
Load Profiles (Apartments in Yerevan)



Source: Hagler Bailly

In order to develop improved information on end-use consumption and demographics, a brief consumer survey of approximately 300 households was completed. This data, as summarized in Exhibit 3, was incorporated into the development of the screening model. It was also used primarily to evaluate the potential impact of the Energy Regulatory Commission’s nighttime tariff.

Exhibit 3
Residential Consumer Characteristics Based on a Household Survey

Information Description	Choice	Yerevan (Komitas)			Abovian			Total		
		Apts	Houses	Total	Apts	Houses	Total	Apts	Houses	Total
Demographics										
Number of people residing	Average	4	4	4	4	4	4	4	4	4
Number of bedrooms	Average	2	3	3	2	3	3	2	3	3
Length at location (years)	Average	21	36	29	5	34	24	15	35	27
Questions										
Gas cooking	Yes	66.7%	90.2%	79.7%	79.0%	97.4%	91.4%	71.2%	93.8%	84.9%
	No	33.3%	9.8%	20.3%	21.1%	2.6%	8.6%	28.9%	6.3%	15.2%
Gas heating	Yes	0%	75.6%	41.9%	0%	97.4%	65.5%	0%	86.3%	52.3%
	No	100%	24.4%	58.1%	100%	2.6%	34.5%	100%	13.8%	47.7%

Source: *Armenia - Interim Results of Pilot on Nighttime Electric Tariff*, Hagler Bailly, November 1999

To develop information on environmental impacts, the focus was on the emissions from the existing natural gas fired generating units. Other impacts, such as water pollution, were not considered in this effort since the impact on power supply was considered to be the primary concern.

DSM SCREENING MODEL

A spreadsheet-based screening model was developed to evaluate the potential cost-effectiveness of various energy efficiency measures, from the perspective of the end user.[2] It also estimates the

[2] There are, of course, many perspectives from which to evaluate the effectiveness of an energy efficiency measure or demand-side program. In the United States, a series of tests have commonly been promoted including the Ratepayer Impact Measure, Total Resource Cost test, the Utility Cost test, the Societal test and the Participant test. The screening tool more closely aligns with the Participant test but also includes environmental impacts so that some measure of the societal impact can also be estimated. In Armenia, with tariffs below full costs, it is probable that any measure which passes the Participant test can also be cost-

impact on emissions resulting from adoption of the new technologies. The model has default data, such as costs, energy tariffs, operating characteristics, and emissions but also allows the user to input values for each that may be more pertinent to the efficiency measure being investigated.

In developing the model, fourteen energy efficiency measures were tested. Exhibit 4 shows both the new replacement technology examined and the existing (or old) technology being replaced.

effective from both the Total Resource and Societal Cost perspectives, unless the program costs to promote the measure are very costly.

Exhibit 4
Energy Efficiency Measures Examined Through the Demand-Side Screening Tool

Measure	New Technologies	Old Technologies
Weatherization	Weatherization & Electric Resistance Heaters	Electric Resistance Heaters
Micro-Boilers & Cooking	Micro-Boilers & Cooking	Electric Resistance Heaters
Central Boilers	Central Boilers	Electric Resistance Heaters
Small Electric Geothermal Heat Pumps	Small Electric Geothermal Heat Pumps	Electric Resistance Heaters
Large Electric Waste Heat Pumps	Large Electric Waste Heat Pumps	Electric Resistance Heaters
Large Gas Engine Driven Geothermal Heat Pumps	Large Gas Engine Driven Geothermal Heat Pumps	Electric Resistance Heaters
Small Gas Heaters & Domestic Hot Water Heaters & Cooking	Small Gas Heaters & Domestic Hot Water Heaters & Cooking	Electric Resistance Heaters
Gas Cooking	Gas Cooking	Electric Cooking
Fuel Cell Cogenerators	Fuel Cell Cogenerators	Grid Equivalent & Electric Resistance Heaters
Natural Gas Engine Cogenerators	Natural Gas Engine Cogenerators	Grid equivalent & Electric Resistance Heaters
Wind Turbines	Wind Turbines	Grid Equivalent
Street Lights	Sodium Street Lights	Mercury Vapor Street Lights
Room Lights	Compact Fluorescent Room Lights	Incandescent Room Lights
Televisions (lower energy use)	Televisions (lower energy use)	Televisions

Those measures that passed the cost-effectiveness criterion and that offer potential for promotion in Armenia are shown in Exhibit 5. The exhibit shows the estimated reduction by measure in non-coincident peak electricity usage if all consumers implemented this measure; in other words, it is the full technical potential of the measure assuming 100% adoption by consumers. Such a level of adoption is of course highly unlikely. It is more reasonable to expect a much lower rate of adoption; if international experience is a guide, then penetration rates of 5-30% are a more reasonable estimate of the practical level of savings that may be achieved in the near to mid-term (i.e., within the first five years).

Exhibit 5
Measures Passing the Initial Screening and Technical Potential Assuming Full Adoption (100% Market Penetration)

Description of Measure	Savings to Investment Ratio (SIR)		Estimated Reduction (Non-coincident Technical Potential)
	Residential	Medium Voltage	
Weatherization	1.5	1.2	42 MW
Central Boilers	1.6	1.1	154 MW
Large Electric Waste Heat Pump	1.0	n.a.	73 MW
Gas Heating, Gas Domestic Hot Water Heating and Cooking	1.0	n.a.	172 MW
Sodium Vapor Street Lighting	1.0	n.a.	12 MW
Compact Fluorescent Lighting	3.8	3.0	66 MW

Source: Hagler Bailly

Given the importance of the planned closure of the ANPP and the need for replacement power, an estimate was also developed of the amount of energy efficiency that could reasonably be expected to be achieved by the winter of 2003-2004, in time to offset some of the replacement power needs. These estimates were based on expert opinion as to the potential contribution in the reduction of system peak load (based on assumed coincidence factors per measure) and energy production at the busbar, for the measures examined and found to be cost-effective for the participating consumer.

Assuming modest efforts to implement a program are initiated within the next six to twelve months, about 42 MWs of coincident system peak coincident savings could be achieved at an estimated measure cost of about US $18.9 million (not including program costs such as program design, administration, and monitoring/evaluation). Annual energy savings would be approximately 203 GWh.[3]

[3] The total non-coincident capacity savings are estimated to be 71 MW.

Exhibit 6
Estimated Savings and Measure Costs for 2003-2004

Description of Measure	Market Penetration Achievable by 2003-2004 (%)	Estimated Savings		Measure Costs (2000 $ Million)
		MW (Coincident Winter)	Annual Energy (GWh)	
Weatherization	33	8.4	37	5.5
Central Boilers	20	19.6	80	4.5
Large Electric Waste Heat Pump	5	0.6	6	0.9
Gas Heating, Gas Domestic Hot Water Heating and Cooking	10	4.2	43	5.4
Sodium Vapor Street Lighting	20	1.0	4	0.5
Compact Fluorescent Lighting	30	8.4	28	1.2
TOTAL	-	42.2	203	18.9

Source: Hagler Bailly.
Note: The measure costs do not include the costs associated with developing, administering and evaluating a promotional program. Also, the MW (coincident winter) estimated savings do not include the possible capacity savings resulting from avoided generating reserves. This impact will be evaluated through the least cost planning exercise presently underway.

The screening model also uses current data, obtained from the Government of Armenia, on emissions from the electric generating plants. This data was provided in kilograms per year for CO_2, SO_X and NO_X. For those measures found to be cost-effective, the estimated reductions in emissions is shown in Exhibit 7 assuming that natural gas fired generation from existing thermal units is displaced.

Exhibit 7
Reduction in Emissions by 2003-2004
(Assumes Market Penetration Rates and Energy Savings Shown in Exhibit 6)

Description of Measures	**Annual Reduction**		
	CO_2	**NO_X**	**SO_X**
Weatherization	255 Mg	193 kg	1.3 kg
Central Boilers	228 Mg	170 kg	1.2 kg
Large Electric Waste Heat Pumps	66 Mg	50 kg	0.4 kg
Gas Heating, Domestic Hot Water Heating & Cooking	124 Mg	94 kg	0.7 kg
Sodium Vapor Street Lighting	315 Mg	239 kg	1.8 kg
Compact Fluorescent Lighting	322 Mg	244 kg	1.8 kg
TOTAL	1,310 Mg	990 kg	7.2 kg

Source: Hagler Bailly
Note: Reductions are based on the assumption that natural gas fired generation is displaced.

As part of the modeling activities underway to develop the least cost generation expansion plan for Armenia, improved modeling and estimation of the environmental impact of energy efficiency (and in fact of all resource options) will be reviewed using a production simulation model. This will provide a more robust estimate of the environmental impact resulting from avoided generation of electricity.

FINANCING MECHANISMS FOR ENERGY EFFICIENCY

The project also developed a recommendation for a mechanism that could be set up in Armenia (or ideally in the Caucasus region) to help finance energy efficiency projects. The recommendation is to develop an energy efficiency revolving fund that would provide low interest funding to qualified participants for cost-effective projects.

The current situation in Armenia, as in the other countries of the Newly Independent States, makes it difficult to finance energy efficiency projects using commercial mechanisms normally employed in other developed nations. The poor economic situation, together with inadequate financial institutions and lack of capital, creates a situation in which energy efficiency projects cannot be easily completed. Funding that is available for credit-worthy consumers is very expensive (annual interest rates exceeding 40%).

Therefore, a proposal for creating a revolving fund for energy efficiency projects was developed. The overall purpose of the fund is to provide the capital needed for cost-effective energy efficiency projects in facilities where normal commercial funding is not yet available. The fund would provide loans for projects at concessionary rates well below the current lending rates in Armenia. Qualified projects would be those with a relatively short payback period. The repayment of the loans would help generate the capital necessary for other cost-effective energy efficiency projects in Armenia or the broader region.

The intent of the fund is to improve existing operations in Armenia with new, efficient technologies. Therefore, the fund would provide financing for qualified energy efficiency and renewable projects including: (1) efficiency improvements for qualified end-users (residential, commercial, industrial, and perhaps governmental); (2) improvements in energy projects, which solve environmental problems. Preference could be given to those projects using local labor and manufacturing to help spur growth of the energy services industry.

The initial capital for the fund would need to come from grants or interest free loans from donor organizations, charities or other humanitarian contributors. These donors could be domestic, foreign or multilateral although significant domestic donations is very unlikely. If the fund could be established regionally, perhaps as part of a reconstruction package assuming resolution of the conflict between Azerbaijan and Armenia, then several new sources of funding may become available. Further, another source of funding could be the use of funds resulting from the sale of greenhouse gas emission offsets. Practically, however, this latter source of funding would prove difficult to achieve in the near-term given that significant institutional development work would be required before hand.

The fund’s principle would be sustained by repayment from project loans over time. Of course, bad debt and inflation would cause dilution in the principle unless there were additional injections of capital into the fund over time, or the interest on the loans was set at a rate to allow the principle to remain constant in real terms. The fund’s administrative costs would be covered by the interest payments on its project loans.

Based on discussions with capital market advisors in Armenia, a suggestion was made to complete projects (those above a certain size) in three stages. Each stage contains one or more discrete energy efficiency or renewable energy measures that may, if necessary, operate without further improvement. The reason for the three stages is to encourage the loan recipient to maintain savings and make payments on the loan in order to qualify for subsequent assistance. Further, this helps to develop a credit history for the borrower.

One way to use this tiered approach is to seek out those projects that could include either: a set of different measures that can be built in successive stages (e.g., lighting replacements, motor replacements, repairing/replacing steam traps, repairing compressed air systems, etc.); or, subsets of one large energy efficiency measure (e.g., grouping of steam traps into three subsets, one boiler at a time, etc.)

Although there may be some benefits associated with a three-stage approach, its use has to be balanced against other conflicting objectives. For instance, the three-stage approach could result in a delay in achieving the savings because a full package of measures would not be implemented simultaneously. Further, higher administrative costs would result thus decreasing the overall cost-effectiveness of the initiative. Finally, if one of the primary reasons for the fund is to promote energy efficiency as a replacement power strategy to compensate for the shutdown of the ANPP, then the delay in the timing of the savings would argue against the use of a tiered approach. The energy efficiency fund approach is described more extensively in the Hagler Bailly report *Financing Energy Efficiency in Armenia* (March 2000).

RECOMMENDATIONS

Based on the work completed during this subtask, several areas of further effort are recommended. All of these recommendations can be completed under current ongoing USAID activities:

1. As part of the effort to develop a least cost generation expansion plan now underway, explicitly model potential energy efficiency measures passing the screening tool to better estimate: (1) their actual economic benefit and relative cost effectiveness in comparison with all resource options; and, (2) the potential environmental impact the measures may represent. Ultimately, the benefit of a demand-side program in monetary terms can be best determined by its impact on the costs needed to meet the country's energy needs. This can be most accurately assessed through a least cost planning analysis: further, this analysis will provide a much better indication of the potential societal benefits resulting from an energy efficiency program.

2. Use the results of the least cost planning process (in terms of economic and environmental impacts) to update the screening tool. Additionally, consider whether the Armenian chapter of the Association of Energy Engineers can take a lead role in promoting the use and training of the screening tool. In the near-term, however, Hagler Bailly should provide additional user training for the screening tool.

3. Design and implement a pilot weatherization and fuel substitution program to confirm the savings estimates found in the current version of the screening tool. Further, more work is needed to estimate the program administrative costs associated with a demand-side program, a task that can also be accomplished through the development and implementation of the pilot project.

4. As part of the effort to examine more rural based commercialization improvements (in areas such as metering, billing and collection), collect saturation information for rural consumers so that a better estimate of the economic potential for energy efficiency can be determined.

5. From a policy perspective, accelerate the dialogue with the Energy Regulatory Commission on energy efficiency and the Commission's role in promoting efficiency. Hagler Bailly will be developing a regulatory policy paper discussing the ways in which a regulatory body can promote energy efficiency. Additionally, at least two staff of the Energy Regulatory Commission should be trained in the use of the screening tool and the ways to evaluate demand-side programs.

Finally, and perhaps most importantly, energy efficiency and the environmental benefits it offers, represent an important regional issue. In this regard, further consideration should be given to ways to increase the dialogue on energy efficiency and methods of promotion between the nations in the region.