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INTEGRATED POWER SECTOR EFFICIENCY ANALYSIS: A CASE STUDY OF COSTA RICA

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ABSTRACT

In an effort to analyze and document the potential for power sector efficiency improvements from generation to end-use, the Agency for International Development and the Government of Costa Rica are jointly conducting an integrated power sector efficiency analysis. Potential for energy and cost savings in power plants, transmission and distribution, and demand-side management programs are being evaluated. The product of this study will be an integrated investment plan for the Instituto Costarricense de Electricidad, incorporating both supply and demand side investment options. This paper presents the methodology employed in the study, as well as preliminary estimates of the results of the study.

INTRODUCTION

Many electric power utilities in developing countries are facing severe financial pressures, due to a combination of heavy debt burdens and inadequate tariff structures to cover cost of service. Traditional approaches to address needs for expanded capacity may no longer be affordable or advisable; the "business as usual" approach of construction of new and larger capital assets will likely have to change in the years to come (A.I.D., 1987).

Solutions to the critical problems facing many electric utilities are not obvious. In many cases, the solutions will lie in the political realm, rather then in technology. However, some non-traditional technical approaches to providing services certainly can and should begin to play a role in utility planning. Integrated utility planning, a concept that has only recently enjoyed a measure of acceptance in the United States and other industrialized countries, synthesizes many themes that may be appropriate to the problems facing developing country utilities. Private participation in power generation; utility based and financed conservation programs; in-house efficiency improvement programs (including line loss reduction, as well as technical improvements to generation equipment); time of day tariff structures, all can be compared to generation options to help electric utilities better control the need for future investments in expensive power plants.

These many and varied options, under the rubric of integrated utility planning (or least cost utility planning), are gaining in acceptance and interest in many developing countries, for reducing expansion costs. In many cases, price subsidies have placed power utilities at great risk, with the problems compounded by high demand growth rates, and unexpectedly high debt service due (in some cases) to currency devaluations. Options to manage demand growth, either through conventional energy conservation measures, or through the introduction of comprehensive energy efficiency programs, are under serious consideration.

In a project sponsored by the Office of Energy/Agency for International Development (A.I.D.), a comprehensive assessment of electric power efficiency opportunities is being conducted jointly by A.I.D. and the Instituto Costarricense de Electricidad (ICE) in Costa Rica. The objective of this project is to evaluate demand side management opportunities; transmission and distribution system line loss reduction; supply side efficiency improvements; and capacity expansion, with the goal of maximizing investment efficiency of ICE capital to meet future electric power needs in Costa Rica.

This paper will describe the process of the Costa Rican project, providing preliminary findings as they are available at the time of this draft. As the project is in progress, final results are not yet available. However, preliminary estimates of the projects findings will be presented. The paper will also briefly describe how this effort will contribute to a global efficiency strategy presently under consideration by A.I.D.

INTEGRATED UTILITY PLANNING IN THE UNITED STATES

The least-cost energy strategy was first articulated by Roger Sant (1979) at the Mellon Institute. In a major study directed toward evaluating the potential energy savings that would result from use of least cost planning strategies – maximizing the efficiency of energy use – this least-cost planning strategy was linked with the concept of sustainable resource development (SERI 1981). This exploratory analysis was performed by several organizations under the guidance of John Sawhill, and the resulting "Sawhill Report" was originally titled "Report on Building a Sustainable Energy Future."

Integrated utility planning for electric utilities refers to a process of balancing the mix of "supply-side" and "demand-side" technologies to provide electricity to society most effectively. The term "least cost planning" (LCP) is sometimes used to describe this balancing process, but the term "integrated resource planning" has been suggested as more appropriate (Gellings et al 1987). Gellings also describes differences between the perspectives and focus of what are usually considered least cost planning and demand side management (DSM). Integrated resource (or utility) planning results from "a convergence of LCP and DSM." DSM encompasses methods and activities that modify how and/or when electric power is used to benefit both the utility and the customer. LCP grew out of a perceived need to develop a new framework for meeting energy user's needs, with particular attention toward making better use of existing energy supplies.

Integrated utility planning is being used by several utilities throughout the United States, but perhaps the most visible and widely-known planning efforts are those in the Pacific Northwest and New England. Governors of New England states endorsed an integrated plan to meet future regional electricity needs, by means of a cooperative planning and resource development effort. Utilities and state agencies in New England are working together to implement major energy conservation and load management (C&LM) programs. These programs are expected to increase C&LM "resources" to represent a major fraction of total electric resources by the year 2010.

In a similar effort, state governments and utilities in the Pacific Northwest have entered into a compact to develop and adopt a 20 year electric power plan to ensure an affordable and reliable electric power supply, using integrated planning principles. The power plan has been developed by the Northwest Power Planning Council (NWPPC), in conjunction with other parties in the region. Efficiency measures for end users and generation are an important part of the overall plan – estimated to account for about 3,000 MW by the year 2010 (NWPPC 1989), just as they are an important part of the current efficiency study for Costa Rica.

An interesting description of an integrated resource plan and planning process by Hirst and Knutsen (1988) describes many of the salient issues. The planning process was developed at Puget Sound Power and Light, a utility located in the Pacific Northwest. The description covers available power for purchase, existing generation station efficiency options, construction of new plants – including combined-cycle combustion turbines, end use efficiency options, considerations for transmission and distribution options, overall integration of analytical methods, and a public involvement effort. The description is valuable due to the broad scope of topics presented, which would benefit anyone wanting a sketch of the overall process.

Integrated utility planning is being pursued in the United States to meet the needs of utilities in the 1990's and beyond. The integrated power sector efficiency assessment is one part of the overall process and is intended to help guide power sector policy in Costa Rica over the next 20 years.

COSTA RICA POWER SECTOR OVERVIEW

Power sector policy in Costa Rica is formulated by a group of government agencies, including ICE, the Servicio Nacional de Electricidad, (SNE); and the Direccion Sectorial de Energia (DSE). In practice, ICE formulates its planning process internally. SNE regulates requests for tariff adjustments and permitting for hydropower development. DSE plays a support role in power sector policy setting, limited to sectoral and cross-sectoral analyses to define policy options for future needs. Actual policy setting functions are directed by SNE and ICE.

ICE can be characterized as a very well run and organized utility. It is state owned and operated, and was established in 1949 to generate, transmit, and distribute power to both urban and rural customers in Costa Rica. ICE's original mandate was to develop Costa Rica's abundant hydroelectric resources. It was also directed to establish an interconnected electric grid, linking generation facilities operated by ICE, as well as those facilities owned and operated by a small group of private producers.

Today, ICE's primary role is to generate electric energy. ICE sells bulk power to distribution utilities, including a group of three municipal utilities and four rural electric cooperatives. It also distributes power directly to roughly one third of all connected users in the national grid. Annual bulk power sales total 1400 GWh/yr to the rural cooperatives and municipal utilities, while ICE distributes approximately 701 GWh/yr to its customers (ICE, 1989).

The capacity mix is dominated by hydroelectric power plants, with 717 MW of installed capacity at eight sites (see Table 1). In addition, ICE has 141 MW of installed thermal capacity, but these power stations have been largely neglected in recent years and will require refurbishment before they can be used to provide firm power in the future.

Electrification has long been a priority for the Costa Rican government. Estimates indicate that up to 85% of Costa Ricans now have access to electric power. This has been accomplished by aggressive efforts to establish and support four rural electric cooperatives and provide power to rural residents directly through ICE distribution systems in areas not served by the cooperatives. The cooperatives presently serve 57,600 customers; municipal utilities provide service to an additional 315,800 customers; ICE provides service to 238,880 customers (see Table 2).

As Figures 1A and 1B illustrate, demand growth has been very high, averaging over 6% from 1981 to 1989. Capacity expansion has been delayed, due to heavy external debt burdens (valued in 1989 at $670 million), and a tariff structure that does not allow ICE to operate with sufficient margins to finance expansion projects. Table 3 illustrates ICE's tariff structure relative to other Central American utilities, many of which have similar capacity mixes and load profiles.

ICE's financial difficulties have been compounded by a series of currency devaluations, leading to yet greater debt burdens. The utility's ability to provide reliable services to its customer base has thereby been placed in jeopardy, with dramatic measures now necessary to assure that the situation can be resolved.

Due to these factors, the government has been exploring opportunities to limit demand growth, and improve overall efficiency of the integrated electric power system. The study described in the following section was designed to develop a strategy to mitigate the effects of the impending crisis. While the project was designed to directly benefit ICE and the Costa Rican economy, the methodology developed should certainly be applicable to several other developing countries. This initiative is representative of an effort to integrate least cost utility planning into future power sector loan programs not only in Costa Rica and Latin America, but in developing countries in general.

COSTA RICA CASE STUDY

The A.I.D. project to identify and quantify economically attractive efficiency improvements is the result of a multi-agency effort, including principals from Costa Rica (Instituto Costarricense, Ministry of Natural Resources, Energy and Mines, and the Direccion Sectoral de Energia); the Agency for International Development; the Inter-American Development Bank; and in an advisory role, the World Bank. The primary output of the project will be an investment portfolio, consisting of a listing of investments in new capacity, efficiency measures to be considered within ICE's existing system and equipment, and investments in demand side management, including development of a comprehensive conservation program. These investment opportunities will be ranked by cost and effectiveness, and will be analyzed in terms of their impact on the power sector against a number of load growth and market penetration scenarios (estimating the effectiveness of the acceptance of demand side management efforts).

To support this product, the project will generate analyses of efficiency measures in production and utilization of electric energy. Secondary products, therefore, will include the methodology employed; the results of each task in the analysis; identification of the limitations of such an analysis; and the research, equipment, and institutional issues identified in the course of this study. Figure 2 provides a flow chart of the tasks, the interim products derived from these activities, and the final products produced by the project.

The project itself has been structured in three phases. The first phase will consist of an assessment of the status of the power sector, data collection to determine the relevant efficiency measures, and to assess the success of efficiency and conservation programs already implemented by ICE and DSE to date.

The second phase of the project will be an analytical phase. The data collected in phase one will be analyzed to determine the technical and economic viability of various efficiency measures identified, with the final objective to rank each respective efficiency "project" against other alternatives.

Included in this second phase will be an analysis of the potential impact of demand side management programs, the sectors that could have a significant impact, the technologies that could be employed (by sector and end use), as well as possible sources of financing and implementation for the programs. This could be perhaps the most problematic part of the assessment, due to the fact that these programs are heavily dependent on the participation of a large base of end users to be cost effective to the implementing agency. Estimates and data describing market penetration potential is limited, and to date there has been little experience with demand side management programs in Costa Rica, or any other developing country, for that matter.

The last phase of the project will involve integration of the technical analysis of each independent efficiency option within a comprehensive utility planning model, developed to assist in this process of least cost planning. When the integration is complete and verified, the investment plan will be discussed with lending institutions to consolidate support for future actions. This process will be performed with the full participation of the Costa Rican principals, taking into consideration reasonable capital, institutional, and technical constraints faced by the utility and the country. Results from this phase will also be used to structure future efficiency projects in selected A.I.D. assisted countries.

The assessment (phase 1) has been designed to gather data and analyze information in four areas. These areas include:

- o Generation and T&D
- o Demand side management
- o Economic and financial factors

o Integrated planning

The first task has been designed to assess the potential for improvement of conversion efficiency and management of existing facilities, including both generation, as well as transmission and distribution systems in Costa Rica. Thermal and hydroelectric stations will be audited, to assess current management and operating practices, and to determine to what extent efficiency upgrades, and monitoring systems could be used to increase efficiency.

In the case of hydroelectric systems, both control systems (mechanical optimization control systems) and water management algorithms will be reviewed. Advances in both hardware and software will be reviewed to determine if improved control algorithms or hardware would enhance net annual energy output.

ICE has recently negotiated a power plant rehabilitation loan, to refurbish aging gas turbines and steam cycle systems. In this case, the terms of reference for the rehabilitation program will be reviewed to determine if additional efficiency improvements can be made to the thermal units, perhaps to include a monitoring program to allow stack gas analysis, to adjust in fuel/air ratios for maximum efficiency. Maintenance and operating procedures will also be reviewed to determine if management practices could be modified to improve equipment performance.

With respect to transmission and distribution systems, ICE has made significant strides in recent years to reduce both technical and non-technical line losses. ICE estimates overall system losses at 11 percent. However, low voltage distribution systems, particularly non-ICE distribution systems, have not participated in loss reduction efforts. For this reason, while this study will review ICE efforts to reduce high voltage line losses, the emphasis will be placed on a characterization and analysis of the loss reduction potential of lower voltage systems. In addition, the potential for introduction of power electronics equipment, more efficient transformers, and control technologies will be reviewed and analyzed.

The demand side management effort is perhaps the most complex and interesting of this exercise. DSE has performed a series of energy characterization studies, compiling information that can be used to identify opportunities for the residential, commercial, industrial, and agricultural sectors. The data from these studies will be used together with information developed for this study on potential conservation measures to estimate conservation potential for each respective group of electric energy end-uses. Combining the technical analysis with an inventory of conversion equipment sold in Costa Rica, and demographic information with respect to income levels versus energy intensity, supply curves for each conservation measure will be constructed. From this exercise, estimates of energy conservation potential for future years will be projected for each respective sector.

Approximately 30% (900 GWh/yr) of electric energy consumption occurs in the industrial sector. Industrial consumption is dominated by motor loads (95%), with lighting and HVAC equipment accounting for slightly more than 4% of the total. Residential loads consume almost 50% of all energy supplies (1500 GWh/yr), of which cooking, lighting, and refrigeration consume almost 85% of this fraction. The "general sector", a term used to describe the combined public and commercial sector loads, is responsible for consumption of approximately 20% (600 GWh/yr) of total electric energy supplies. Hard data on consumption patterns is not available, but preliminary data indicate an approximate break-down of office equipment, lighting, and HVAC of 79% for this sector.

Conservation opportunities are many and varied. The cost of these opportunities will be an output of the analysis, as will an estimate of the net present value of each of these conservation opportunities to the end users, and to ICE or other sponsoring agencies of the conservation program. Preliminary analyses indicate that the "usual suspects" of attractive conservation measures will include water heating, air conditioning, lighting, and cooking for the domestic sector users; lighting and HVAC for general sector applications; and motor and drive components (efficient belts and pulley retrofits) for industrial applications.

Extensive energy audits will not be performed as part of this phase of the study. Rather, only existing data will be used, with extensive interviews with DSE and ICE personnel in an attempt to gage the limitations of the studies performed in the data collection and analysis process. In most cases, the Costa Rica case study has benefited by the strength of the host collaborating agencies, and the depth and breadth of data available. In many other countries, data of this quality would probably not be available.

In additional to the technical analysis performed on the electric power system, and the opportunity to use energy more efficiently, a parallel economic analysis is being performed to determine both the probable impacts and the limitations under which an integrated efficiency would operate on the Costa Rican economy. This analysis will include a macro-economic overview, and a financial analysis to determine the commercial cost of capital for commercial, industrial, and household loans. In addition, a generalized tariff analysis will be performed to determine the extent to which tariff reforms will affect ICE's ability to finance future investments, and to levelize load regimes.

In the final phase of the study, the integrated planning exercise will be performed. This exercise will employ ELECTROPLAN (Meiers, 1988), a comprehensive planning tool developed recently. This modelling tool allows integration of engineering, dispatching, expansion, and financial modeling tools to determine cost effective utility investment options in a dynamic programming environment. Results from this modelling exercise will be statically verified by a manual analysis.

The investment plan will be a less straight-forward process. This process will require a significant level of interactions with a number of host government counterparts, donor agency representatives, and analysts. The purpose of this exercise is to integrate estimates of the technical and financially attractive investment opportunities with the institutional and political realities and constraints operating within the Costa Rican power sector context. Once the consensus building process is complete, the plan will be formally presented to commercial banks and donor agencies.

PROJECTED IMPACTS ON COSTA RICA

Although data has not been analyzed in detail, preliminary estimates of the potential for efficiency improvements can be performed. These estimates will be refined as the analytical process progresses, together with estimates of costs of efficiency measures as specified by the study.

As mentioned above, transmission system line losses approximate 11 percent. While it may be technically feasible to reduce this figure to 5% if sufficient capital were available, it is improbable the investment necessary to allow reductions on this order could be accomplished in the near term. For each percentile reduction in losses, approximately 37.7 GWh of energy can be saved, and as much as approximately 8 MW of capacity. The potential energy savings represents $1.34 million in energy lost revenues to ICE. If a 3% reduction in losses could be accomplished through use of improved distribution and transmission lines, this would result in equivalent annual savings of 113.1 GWh of energy, and up to 24 MW of capacity.

It is important to note that distribution line design is not strictly an engineering task: inherent in the process is a cost/benefit analysis, balancing the benefits of reduction in line losses against the cost of the improved conductor size and type. Therefore, while technically it may be possible to reduce losses by three to five percent, it may not be economically viable to do so.

Estimating net energy savings from generation equipment is equally problematic. Fossil fuel power plants presently account for a small fraction of energy produced, on the order of 375 GWh per year. Assuming this figure is accurate, each percentage increase in prime mover efficiency would account for an annual fuel savings of 1.34 million gallons of distillate fuel. If a 4% increase in efficiency were possible (averaged over all ICE prime movers), savings of 5.37 million gallons of distillate fuel would be possible (EPRI, 1986).

Increases in hydroelectric energy generation may be possible, if the water use protocol for storage facilities can be improved. Only three hydroelectric sites in Costa Rica have significant dam storage (Corobici, Arenal, and Cachi), but these three facilities represent 60% of the installed hydro capacity. If a five percent increase in energy generation can be accomplished through improved water management at these sites, the gross increase in energy generation will approximate 90 GWh per year. Table 4 summarizes the savings potential for the estimated distribution loss reduction, thermal, and hydro generation efficiency potential for Costa Rica.

In the residential sector, savings for electric stoves appear possible, but acceptance of changes to the preferred electric burners may be difficult according to the local manufacturer. Disc-type burners are preferred now. Spiral burners are typically not used because they cost more, allow food to fall through, and are not as durable. However, according to initial tests performed in Costa Rica, they may be more efficient (25% more). Further study, and perhaps additional research in the future, of the efficiency possibilities for electric stoves is needed.

Refrigerator efficiency can be improved, and the potential savings can be as high as 50%. An example of the type of data used to develop a conservation "resource" supply curve for refrigerators is shown in Figures 3 and 4. These data were developed by Lawrence Berkeley Laboratory as part of an overall assessment of energy savings potential in the residential sector in the United States. In Figure 3, the decreased annual electricity consumption (UEC) is shown decreasing, while the consumer price increases. To gain a better perspective on the relationship between reduction in UEC and price, Figure 4 shows the cost of conserved energy (CCE). CCE is a levelized cost, typically using a 3% real discount rate for electric utilities, used to evaluate technology options to potentially be incorporated in an integrated utility plan for new resources. Of particular interest is the use of evacuated panels (advanced insulation), which are currently an important research item in the United States (Smith and Potter 1990). Likely savings for Costa

Rica could be 20% of refrigeration energy if all refrigerators are replaced, which translates to about 70 GWh/yr.

Water heater tanks can be insulated, with potential savings of about 5-9%. This savings translates to 2-3 GWh/yr. Solar water heating can also be considered and may be very important for the future. Solar water heating systems in Hawaii can save 100% of water heating energy use in many cases, and the same potential appears possible for most of Costa Rica. Not all homes could use solar water heating, but total energy for water heating (other than on the stove) is about 120-150 GWh/yr. If we assume that 40% of the homes that have some type of electric water heating device (other than the stove) could benefit, the potential savings is about 50-60 MWh/yr.

Lighting uses about 300 GWh/yr in the residential sector, of which about 90% of the energy is for incandescent and 10% for fluorescent lighting. About 70% of lighting energy is consumed by urban dwellers and 30% by rural dwellers. If we assume that compact fluorescent lamps can be installed in 40% of the urban households, with an average of 3 incandescent lamps of 50 W replaced by fluorescent lamps at 18 W/lamp would lead to 35 GWh/yr savings.

Thus, the total potential energy savings for the residential sector for all these options is approximately 160 GWh/yr. The potential capacity savings is estimated to be 40 MW for refrigeration and 20 MW for lighting. Capacity savings for hot water is more difficult to judge, since much of the water heating use is in the morning and not coincident with system peaks. The capacity savings is estimated to be about 30 MW for solar water heating, with the assumptions used above. The total capacity estimated savings is 90 MW.

For the general sector, potential electricity use savings can be expected to result from improved energy management and changes to lighting. Energy management could result in an average of 5% savings or 30 GWh/yr. Lighting efficiency changes, including increased use of daylighting could lead to an average 20% savings in lighting energy or 30 GWh/yr. The total energy savings is 60 GWh/yr, and the capacity savings is estimated to be 10 MW for energy management and 20 MW for lighting (total of 30 MW).

The industrial sector has the same potential savings areas as the general sector: energy management and lighting. In addition, we can estimate a savings for improved motor efficiency. Energy management could account for 20 GWh/yr of savings and improved lighting efficiency for 10 GWh/yr. Replacing electric motors so that half of present motor consumption is accounted for by new, more efficient motors, about 30 GWh/yr could be saved. The total energy savings for these options is 60 GWh/yr. The estimated capacity savings is 10 MW for energy management, 7 MW for lighting, and 30 MW for efficient motors, for a total of about 50 MW.

The overall savings for the three sectors is estimated here to be 280 GWh/yr and 170 MW. Keeping in mind the potential economic and practical limitations to achieving these savings, the results described above are summarized in Table 5.

ISSUES AND LIMITATIONS

In the course of developing and implementing this project, issues regarding data limitations, probable technology penetration rates, and technological uncertainties have been identified. These uncertainties call into question the validity of performing a single pass, static analysis of the potential for efficiency measures to mitigate need for capacity expansion.

Perhaps the central issue has to do with the status and nature of energy efficient technologies, and the temporal role they can play in improving electric energy use. Technological improvements are made on almost a continuous basis for power systems equipment, including prime movers; generators; transmission and distribution systems components; dispatching systems; metering methods and equipment; as well as end-use conversion equipment. However, in the technology development process, it takes several years to bring a product from a laboratory proven model to the market place, and usually several years more (depending on the technology and its market) to realize significant market penetration.

This study was designed to profile the cost effective efficiency improvements that could be made at the time of the study, with shelf-available technologies. In performing the analysis, projections were made 20 years into the future, taking only into consideration those technologies that are developed and are cost competitive today.

In a twenty year time frame, we have witnessed a revolution in controls, automation of dispatch and monitoring; significant advances in transmission and distribution equipment; significant advances in prime mover technology efficiencies; and a revolution in end-use technologies. These development would argue for an analysis that could account for likely technological improvements, but one could not factor these projections into the end product, the proposed ICE investment plan.

Some of the more promising technological developments may have far reaching impacts on electric power utilities. Intercooled, steam injected gas turbines could dramatically increase conversion efficiencies for solid fuels, including biomass and coal (Williams, 1989). Closed loop electronic control systems for wicket gate/turbine angle compensation will improve turbine efficiency by several percent for large hydroelectric power plants (Steendahl, 1988). Power electronics, high voltage direct current (HVDC) transmission systems, distribution automation, and reactive compensation could decrease system losses, improve power quality, and increase system reliability to the end user (Reddoch, 1990). Improved motor controls, lighting systems, higher efficiency refrigeration systems, and cooking devices, could all contribute to reducing energy consumption, and in reducing peak demand.

However, we do not know at present when these technologies will be available (at affordable prices), and in sizes and configurations that will best suit developing country markets. Moreover, once they have been developed, the difficult and laborious process of introducing these technologies to their respective markets must begin.

Without a knowledge of when or to what extent these technologies will be introduced, they cannot be incorporated into a planning process. However, as Fulkerson (1989) has suggested, this argues for a planning process that is continual in nature, one in which technology adaptations are identified and reviewed on at least an annual basis to determine how they effect the integrated planning process, and to what extent their use should be supported and perhaps promoted by key agencies in the power sector.

The integrated electric power utility analysis underway in Costa Rica will certainly encounter these and other limitations, but the process will allow planners to view power sector planning from a different perspective, using improved analytical tools, and hopefully, resulting in more capital efficient decisions. In this process, the study will undoubtedly undergo modification, hopefully leading to improvement in the methodology for most or all tasks, changes that will be incorporated into future efforts.

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Figure 1A: ICE load growth.

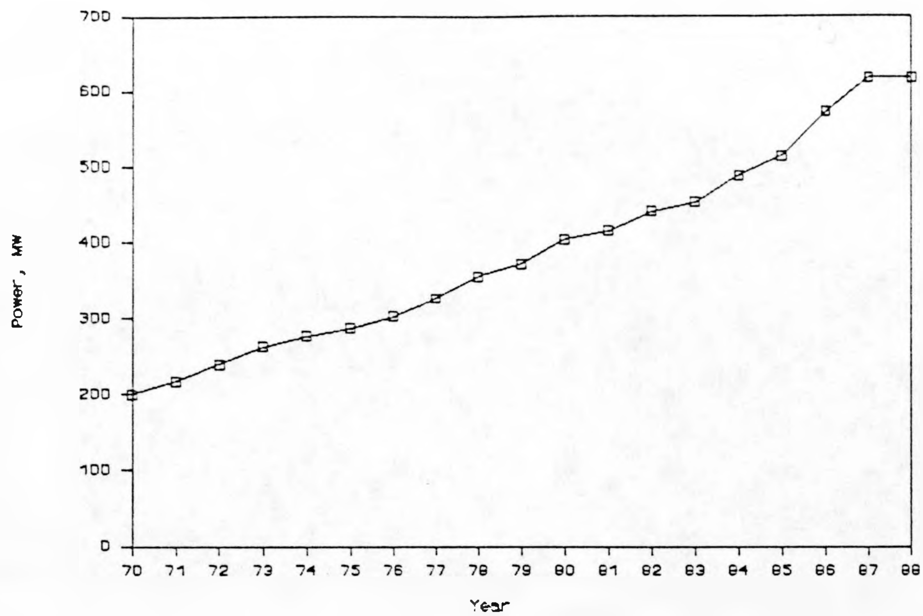

Figure 1B: ICE generation growth.

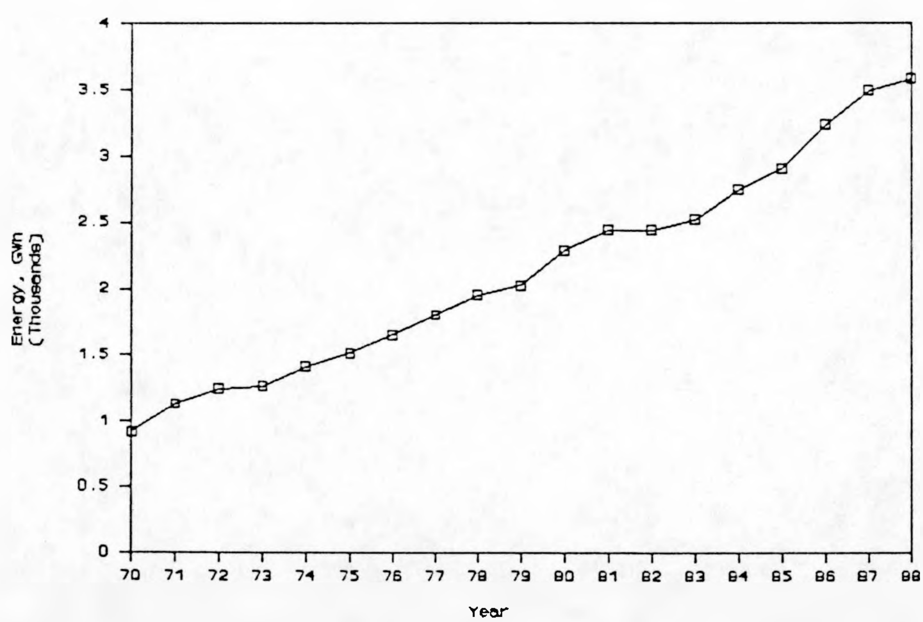

Table 1: ICE and independent power plants.

Plant Name	Type	No. of Units	Installed Capacity (MW)
Corobici	Hydro	3	174
Arenal	Hydro	3	157
Rio Macho	Hydro	5	120
Cachi	Hydro	3	101
La Garita	Hydro	4	130
Colima	Diesel	6	20
San Antonio	Steam/Gas	4	48
Barranca	Gas	2	41
Moin	Diesel	4	32
Small Plants	Hydro	5	2
CNFL	Hydro	19	19
Other	Hydro	9	14
ICE Isolated	Diesel	7	1
		72	859

Source: ICE (1989)

Table 2: Utility statistics.

Utility	No. of Customers	Line Length (km)	Energy Sold (GWh)
I.C.E.	238,880	9265	1376
CNFL	255,000	1900	1542
JASEC	36,496	748	145
ESPH	24,309	300	97
Coop's	57,603	3367	160
	612,288	15580	3320

Source: ICE, 1989.
Note: CNFL, JASEC, and ESPH are municipal utilities.

Table 3: Central American utility average tariff rates (1988).

Country	Residential	Industrial
Panama	$0.1218	$0.1080
Honduras	$0.0603	$0.0517
Guatemala	$0.0429	$0.0579
El Salvador	$0.0407	$0.0468
Costa Rica	$0.0357	$0.0580
Nicaragua	$0.0323	$0.0750

Table 4: Summary of efficiency potential for distribution and generation savings.

Measure	Present Status	Goal	Annual Benefits	Annual Potential Savings (USD)
Distribution Loss Reduction	11%	8%	113.1 GWh	$3.96 M
Fossil P.P Improvement	22%	26%	5.44 M gal	$9.4 M
Hydroelectric Energy	3000 GWh	increase 5%	96 GWh	$3.1 M

Assumptions: Weighted average electricity price of $0.035/kWh (bulk and retail); $1.75/gallon light distillate (economic cost); 4% decrease in line losses; 4% increase in thermal efficiency; 3.2% increase in gross hydroelectric energy (5%*60%).

Table 5: Summary of efficiency potential for end use sectors.

Measure	Present Consumption (GWh/yr)	Energy Savings (GWh/yr)	Capacity Savings (MW)	Total Potential Savings (USD)
Residential				
Advanced refrigerators	350	70	40	2.5 M
Water heating (solar)	140	55	30	1.9 M
Lighting	300	35	20	1.2 M
Subtotal		160	90	5.6 M
General				
Energy management	---	30	10	1.0 M
Lighting	150	30	20	1.0 M
Subtotal		60	30	2.0 M
Industrial				
Energy management	---	20	10	0.7 M
Lighting	70	10	7	0.4 M
Efficient motors	800	30	30	1.0 M
Subtotal		60	50	2.1 M
TOTAL		280	170	9.7 M