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HOUSEHOLD ELECTRICITY CONSUMPTION IN THE PHILIPPINES

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ABSTRACT

Past efforts on energy conservation programs have been directed largely at industrial and commercial establishments, which have traditionally been large energy users. The growing residential power demand, estimated at 6,336 GWh and accounting for 29.7% of 1992 power consumption, also opens prospects for energy conservation.

The study assesses the characteristics of household electricity demand in Metro Manila and identifies areas where demand management schemes can have the greatest impact on the power supply base. The study benefitted largely from the 1989 household energy consumption survey conducted by the then Office of Energy Affairs under the World Bank-Energy Sector Management Assistance Program.

Review of the size and structure of household electricity demand indicates large potential energy savings from the use of more efficient lighting, airconditioning and refrigeration. The cost of conserved energy from the use of efficient energy-using devices is far less than the cost of installing additional power capacity. An intensified and sustained nationwide energy conservation program can significantly required capital investments for power development. Energy conservation also addresses the growing environmental issue while lowering energy imports and thus improving the country's balance of payments position.

The study emphasizes that the gains achieved from earlier efforts can only be sustained and advanced with the synchronization of various efforts from both the legislative and executive branches of government. The support of the private sector, covering the power utilities, media, non-government organizations, and consumers, is also imperative. Among various recommendations, the restructuring of power tariffs is deemed to be the single most effective factor in promoting energy conservation. By providing the right pricing signals, consumers will be compelled to orient their purchasing decisions towards energy-efficient appliances and technologies and to alter their power consumption behavior.

INTRODUCTION

The world has long since witnessed successful demonstrations of energy conservation technologies, both in terms of financial and environmental considerations. However, such technologies have played marginal roles in developing countries' energy supply-demand balances.

The rapid growth in energy consumption in developing countries has raised concern on their capacity to provide for future energy supply. It is estimated that electricity use in developing countries will grow at an average annual rate of 6.6% in the 1990s, with installed generating capacity increasing from 471 GW in 1989 to 855 GW by the end of 1999. This will require US$745 billion in 1989 prices or US$1 trillion in current prices (World Bank, 1990).

In the Philippines, the huge capital investment requirements for power sector development include the installation of long-delayed additions to the baseload capacity. While emphasizing power capacity expansion, the government also accords priority to demand side management (DSM), at least in its policy pronouncements. The International Institute for Energy Conservation defines DSM as the systematic effort to manage the timing and amount of electricity demand, and to increase the overall efficiency of electricity use (IIEC), 1991. One of the strategies adopted in the Philippine Energy Plan for 1992-2000 is to intensify the promotion of energy conservation and energy-efficient technologies. The Plan advocates for a comprehensive DSM scheme using both price and non-price intervention mechanisms (OEA, 1992).

Non-price interventions involve education and information campaigns on energy conservation, supplemented with energy audits and advisory services to energy-intensive industrial and commercial establishments. Further, the Plan declares that the "proposed legislation seeking to institutionalize energy conservation and effect mandatory labelling of appliances will enhance the effectiveness of current efforts to promote energy conservation."

Despite these assertions, however, the extent to which such programs contribute the energy development program is not clear. Instead, the Plan emphasizes additions to the energy supply base. By the year 2000, national energy demand is projected to reach 219.8 million barrels of fuel oil equivalent (MMBFOE). Energy use for the power generation will steadily rise to reach 90.1 MMBFOE, accounting for 35-40% of total energy demand. The on-going revision of the Philippine Energy Plan is expected to target a higher contribution of energy conservation programs to the total energy mix.

The 1993-2005 Power Development Program targets a more stable and adequate level of generation, including the interconnection of the fragmented power network into a single national grid. By 2005, the country's power generation capability shall have increased by 20,698 MW to meet the anticipated annual load growth of 11.3%. It is encouraging to note that the program targets a 17% share for DSM to the energy generation mix by 2005. These measures are expected to contribute to the mix only starting in 1998, however.

A sustained campaign to promote a nationwide energy conservation program can substantially reduce investment requirements for power development. The ESCAP estimates that saving 1 KW of installed power through energy conservation measures costs about US$300 while installing 1 KW of additional power capacity costs approximately US$1,200 (ESCAP-APCTT, 1992). Thus, prospects for such four-fold reduction in investment requirements merit further consideration. The government should now move to translate its policy pronouncements to active and sustainable programs of support.

OBJECTIVES OF THE STUDY

Past efforts at energy conservation programs have been directed largely at industrial and commercial establishments, which have traditionally been large energy users. The growing residential power demand, estimated at 6,336 GWH and accounting for 29.7% of 1992 power consumption, also opens prospects for energy conservation.

This study shall start with an assessment of the characteristics of household electricity demand and shall identify areas where demand management schemes can have the greatest impact on the power supply base. The study shall focus on Metro Manila, which is the largest urban center in the country. However, where necessary, recommendations for nationwide application of identified strategies shall be made.

This study shall take off from the results of the 1989 household energy consumption survey conducted by the Office of Energy Affairs and supported by the World Bank-Energy Sector Management Assistance Program (WB-ESMAP). The survey used a sample of 5,407 households nationwide, spread in approximately the same proportions as the 1988 Family Income and Expenditures Survey. The results of the survey are considered preliminary until the final report from the World Bank is released.

HOUSEHOLD ELECTRICITY DEMAND

Size of Household Electricity Demand

Total power sales of the National Power Corporation (NPC) in 1992 reached 23,769 GWH of which 78.2% was accounted for by Luzon. Mindanao accounted for the other 12.4% while Visayas consumed the remaining 9.4% (see Table 1). From 1980 to 1992, total NPC sales grew by an average rate of 4.5%. In 1986 and 1987, the rate growth peaked at more than 9%. Shortly thereafter, however, the existing power infrastructure suffered breakdowns, without the

Table 1. NPC Power Sales: 1980, 1986-1992 (in GWH)

	1980	1986	1987	1988	1989	1990	1991	1992	G.R.(80-92)
RP	14,033	17,645	19,337	21,180	22,244	22,915	23,598	23,769	4.5%
Luzon	12,164	13,461	14,720	16,078	16,795	17,368	18,123	18,591	3.6%
Visayas	292	1,261	1,490	1,644	1,768	1,818	2,036	2,228	18.5%
Cebu	163	466	573	650	718	725	803	938	15.7%
Negros	32	207	268	322	360	362	423	445	24.5%
Panay	75	156	182	214	224	231	292	328	13.1%
Leyte	5	401	429	416	419	449	463	462	45.8%
Bohol	17	31	38	42	47	51	55	54	10.1%
Mindanao	1,577	2,923	3,127	3,458	3,681	3,729	3,439	2,950	5.4%

Source: NPC

addition of new facilities to serve peak load requirements. Total NPC power sales increased by only 3% from 1990 to 1991 and by only 0.7% in 1992.

Power demand, as measured by NPC sales is grossly understated. In 1992 alone, unserved power demand due to generation deficiency was estimated by NPC at 1,992.75 in contrast to the 537 GWH deficiency recorded in 1991.

As of December 1992, the Manila Electric Company (MERALCO) purchased 14,479 GWH from NPC, representing 77.9% of NPC sales in Luzon and 60.9% of total NPC sales. MERALCO serviced 2.5 million households or 89.8% of potential household connection in its franchise area. The residential power consumption of 3,941 GWH accounted for 32.1% of the total customer sales of 12,279 GWH. The average annual growth of 4.9% in residential power consumption from 1980 to 1992 was relatively faster than the growth in total consumption of 3.4%, indicating the growing importance of efficient energy management in the residential sector (see Table 2).

Table 2. MERALCO Sales by Customer Class (GWH)

	Residential	Commercial	Industrial	Others	Total
1980	2,227	2,617	3,259	112	8,216
1981	2,406	2,681	3,154	102	8,342..
1982	2,570	2,786	3,065	101	8,522..
1983	2,878	2,974	3,215	96	9,163..
1984	2,864	2,708	2,762	94	8,428..
1985	2,831	2,612	2,358	78	7,879..
1986	2,822	2,644	2,391	81	7,938..
1987	3,045	2,932	2,768	83	8,828..
1988	3.326	2,357	3,553	86	10,322..
1989	3,415	3,659	3,890	88	11,052..
1990	3,593	3,813	4,069	90	11,565..
1991	3,754	3,751	4,335	92	11,931..
1992	3,941	3,816	4,430	92	12,279..

Source: MERALCO

For the 122 rural electric cooperatives (RECs), total power sales reached 3,042 GWH in 1992, with Regions III and VI each accounting for around 13.9%. Residential power consumption account for the bulk of total power sales, representing 46.4%. Household consumers in Luzon accounted for almost 54% of residential power sales or 25% of total power sales (see Table 3).

Including other private power utilities, total residential power consumption in 1992 was estimated by the Department of Energy at 6,336 GWH. This represents 24.7% of total end-use consumption, next in importance to industrial power consumption at 35.3%. Residential power consumption increased by 1.4% from 1991 while industrial power consumption declined by 3.0%

Table 3. 1992 Revenue and Sales Data of Electric Cooperatives

Region	Gross Revenue (P000)	Total Sales (MPWH)	Average Systems Rate (P/KWH)	Residential Sales (MWH)
I	1,025,898	315,026	3.25	195,742
II	535,621	154,289	3.47	86,304
III	1,291,112	423,916	3.05	247,547
IV	620,245	193,727	3.20	106,826
V	841,684	255,644	3.29	123,691
VI	1,316,026	420,877	3.13	191,419
VII	527,368	177,283	2.97	73,751
VIII	451,189	131,294	3.44	66,743
IX	391,517	192,904	2.03	68,754
X	567,437	322,993	1.76	96,183
XI	557,099	300,165	1.86	106,677
XII	215,777	100,352	2.15	47,280
TOTAL	7,752,072	3,042,395	2.55	1,410,917

Source: NEA

End-use Demand for Electricity

The 1989 household energy survey confirms the general observation that consumption levels, both in terms of appliance purchases and power consumption, rise with income changes. Table 4 shows that households own more appliances as incomes increase, except for black and white TV sets which are normally replaced by colored sets. The use of manual refrigerators is still prevalent in high-income classes although frostless refrigerators replace manual ones as incomes increase. Low-income households rely more on fluorescent lamps than incandescent lamps despite higher first costs, probably due to lighting quality preferences. At higher income levels, most households have both incandescent and fluorescent lamps. Air-conditioners are widely used in high-income classes which own one or more units (Sathaye, 1991).

Ownership of electric stoves/ovens is more common in high-income than in low-income classes. Almost all households in the middle-and high-income classes own electric fans.

The structure of household electricity demand varies between income classes. The power consumption of low-income groups is only 5% of the average consumption of high-income classes. Lighting accounts for 25% of consumption for the low-income group but declines to 14% and 10% as incomes rise. In the middle income group, refrigerators account for the bulk of electricity consumption. In the high-income group, air-conditioning consumes the greater part

Table 4. Percentage of Households Owning Electric Appliances by End-use and by Income Class

	Low	Medium	High	Average
Lighting				
Incandescent	55	66 82	85 97	72
Fluorescent	73	89 92	98 97	89
Refrigerators				
Manual	21	50 65	85 93	55
Frostless	1	4 14	14 15	7
Air-conditioning	2	1 5	47 87	15
Cooking	5	13 11	36 31	22
Television				
Black & White	42	60 52	32 23	49
Colored	11	32 59	86 93	44
Iron	55	80 86	97 97	81
Fan	68	89 98	97 99	88

Source: 1989 Household Electricity Consumption Survey (HECS)

of the household power bill. Electric cooking accounts for a minor share of total electricity consumption. On the other hand, irons and electric fans eat up 15% and 20%, respectively, of the low-to-middle income households' budget for electricity (see Table 5).

Unofficial data from MERALCO indicate that customers with an average monthly income of less than P12,000 consume less than 200 KWH per month. Using MERALCO's March 1993 bill frequency distribution, residential customers consuming less than 200 KWH account for 81.9% of all residential customers and 49.2% of the total residential consumption of 303.7 GWH (see Table 6). This customer class registered a 9.4% increase in consumption over 1991.

MERALCO enforces a socialized pricing policy whereby customers consuming up to 300 KWH enjoy subsidized tariffs for the first 50 KWH. Customers consuming up to 50 KWH represent 22.2% of all residential customers but consume only 4.0% of total residential consumption. Households consuming over 500 KWH per month account for only 3.5% of all residential customers but account for 22.3% of total residential consumption.

Starting in August, MERALCO's generation charge will be P2.376/kWh for subsidizing customers. Subsidized customers will continue to be charged P0.85/kWh. For both types of customers, the following distribution charge schedule is applied: P6.50 for the first 10 kWh, P0.65/kWh for the next 40 kWh, and P0.80/kWh for consumption greater than 40 kWh. A currency exchange rate adjustment (CERA) of 4.31% is also applied to the basic distribution charge in excess of the first 50 KWH per month.

Table 5. Electricity Consumption by End-use and by Income Class (in %)

End-Use	Low	Medium	High
Lighting	25	14	10
Incandescent	12	5	6
Fluorescent	13	9	4
Refrigerator	18	30	11
Manual	15	27	9
Frostless	3	3	2
Air-conditioning	6	6	55
Cooking	5	8	5
Iron	15	15	5
Fan	20	17	4
KWH Cons./HH	60	300	1,200

Source: 1989 HECS

Table 6. MERALCO's Bill Frequency Distribution, March 1993

Consumption Bracket (KWH)	No. of Customers	Cumulative Share	Consumption (000 KWH)	Cumulative Share
0 - 50	438,488	22.2%	12,058	4.0%
51 - 100	523,401	48.7%	41,139	17.5%
101 - 150	421,027	70.0%	54,024	35.3%
151 - 200	235,494	81.9%	42,260	49.2%
201 - 250	124,430	88.2%	28,805	58.7%
251 - 500	165,787	96.5%	57,562	77.7%
501 -1000	49,286	99.0%	34,627	89.1%
1001 -OVER	18,980	100.0%	33,253	100.0%
TOTAL	1,976,893		303,728	

Source: MERALCO

Target Sectors for Potential Energy Conservation/Load Management Programs

The size and structure of household electricity demand indicate large potential energy savings through energy demand management from lighting, air-conditioning, and refrigerators. This selection, however, does not preclude the need for altering consumption behavior with regard to other end-uses. This selection is made mainly on the basis of the availability of more efficient technologies. Other-end-uses also need to be covered by energy conservation programs where information campaigns may be a potent force to influence consumption patterns.

REVIEW OF RELATED EXPERIENCE AND OTHER STUDIES

The Center for Building Science estimates that the introduction of CFLs in the United States will save 50% of the 200 billion kWh used annually by incandescent lamps (1990). The savings of 100 billion kWh (4% of all electricity) is worth $7.5 billion per year in energy bills, and $29 billion in avoided investments in power plants.

In Austin, Texas, a conservation subsidiary of a utility and telecommunications company offered to retrofit the lighting system of an apartment building and guaranteed a cut in lighting costs of 70%, plus or minus 10%. After meeting the guaranteed savings projections, the district manager of a large property complex agreed to retrofit the remaining 37 buildings (MacInnis, 1987).

Citing a survey by the Energy User News (EUN) Magazine in the United States, Geberer (1987) reports that "the number of utilities offering rebate programs for commercial and industrial users has more than tripled in the last three and a half years, with lighting equipment and thermai energy storage the fastest growing rebate technologies/" Rebates benefit the user by cutting his overall operating costs while the utility avoids the need for installing additional capacity. Payments, usually a fixed dollar amount per kilowatt eliminated or per kilowatt shifted to off-peak hours, are based on the utility's avoided cost. In one of EUN's interviews, a senior economist for the Alliance to Save Energy attributes the increase in the number of rebate programs to the success of rebates in the residential sector through such programs as the Residential Conservation Service established in 1978. He also observed that customers respond more readily to cash up-front payments than loans.

From an interview with Mr. Mark Cherniack and Mr. Peter Rumsey of the Asia Office of HEC in Bangkok, Thailand in September 1992, rebate programs in the United States (involving the distribution of two CFLs per customer who are required to pay back in 24 equal monthly installments) were reportedly not successful. From the utility's perspective, servicing 250,000 loans at US$20 each was not cost-effective. Besides, consumer response to these programs were very low.

In Europe, 40 residential lighting programs have altogether introduced about 2 million compact fluorescent lamps into almost 5 million eligible households (Mills, et al, 1990). The programs were found to be cost-effective, saving electricity at an average cost of about 2 cents/kWh compared to a cost of about 6 cents/kWh for new power capacity. A very broad range of strategies employed to stimulate increased use of CFLs include mail and door-to-door giveaways (to utility employees and/or customers), direct installation, rebates and other forms of retail discounts, wholesale discounts, government subsidies to lamp buyers or utilities, government removal of special taxes, bulk lamp purchase with savings split between utilities and retailers, pay-on-the-bill approaches, and retail outlets independently offering special discounts after completion of a utility program. In various combinations, utilities, lamp manufacturers, wholesalers, retailers, and government agencies have helped to finance and operate the programs. Such programs can be carried out in weeks or months, although care should be taken to provide coordination between programs and manufacturers to insure that a sufficient supply of efficient lamps is available for future programs.

In Thailand, a five-year master plan on DSM for Thailand's electric power system was completed by the HEC in November 1991 (HEC, 1991). The US$183 million DSM program was approved by the government of Thailand and is now being implemented. The three state-owned electric utilities - Electricity Generating Authority of Thailand (EGAT), the Metropolitan Electricity Authority (MEA), and the Provincial Electricity Authority (PEA) - have jointly formed a DSM Office to manage the program. The program offers financial incentives to homeowners, business and industry to buy more efficient electricity-using products and technologies. The budget also allocates funds for training utility management and technical staff; marketing the DSM programs; program evaluation costs; program administration; and load management research.

The HEC estimates that the program can avoid the installation of 2000 MW of power plant capacity costing 99 billion baht, as opposed to the cost of saving 2000 MW through efficiency improvements costing only 40 billion baht. The HEC also recommends that utilities pay for DSM measures that cost less than 1.56 baht/kWh, even though EGAT's long-term avoided cost is only 1.08 baht/kWh This recommendation is justified on the grounds that DSM measures cause little or no pollution, and thus should be given an environmental credit (of at least 15%) in comparison with supply-side options. DSM measures should be given credit for avoiding the need to provide for reserve margins (15%), and transmission and distribution losses (14%).

The World Bank's Global Environmental Facility (GEF) has recently contracted the HEC to prepare a pre-investment study that will examine how Thailand's DSM program can effectively use GEF funds for improving electricity efficiency. The study will also document the training process for the DSM Program Office, government agencies, and private sector firms. Upon completion of the study, the GEF is expected to provide Thailand with US$15 million in grants for the program, with an additional US$ 15 million in soft loans (HEC, 1992). Complementing the DSM program is the establishment of the Energy Conservation Fund (ECF) which provides grants for cogeneration, renewable energy, monitoring and evaluation, etc. Fund sources include the oil price equalization fund (amounting to US$60 million) and taxes from natural gas and petroleum (amounting to US$55 million annually).

Despite successful case studies of energy conservation, the implementation of energy conservation technologies in developing countries has been very slow. Monasinghe cites a review of thirty country energy studies which identified the following constraints to effective energy conservation (Monasinghe, 1990):

a. *poor awareness* due to lack of understanding of the problem and inadequate information;
b. *incorrect attitude* arising from misconception that energy conservation implies deprivation or sacrifice;
c. *weak institutions*, both from the government and private sector organizations;

d. *insufficient technical know-how* which constrains the ability to diagnose, design and implement technical solutions to energy efficiency related problems;
e. *economic and market distortions* which inhibit rational response to conservation measures; and
f. *capital shortages.*

The following corrective measures were also identified: (a) educational and promotional activities; (b) improved legislation; (c) reorganization of the institutional framework; (d) technical assistance and energy audit training; (e) rational pricing policies; (f) economic, fiscal and trade policies; and (g) financial assistance and allocation of funds.

PRIVATE SECTOR AND GOVERNMENT INITIATIVES

Riding on the global trend towards a clean environment through more efficient energy utilization and on the current power crisis, local manufacturers, with or without government support, are taking the initiative to promote energy management programs. One such example is the campaign of Philips Electronics & Lighting, Inc. for its TLD fluorescent lamp which saves 10% on electricity (18 watts vs. the standard 20 watts lamp).

Philips recently relaunched its SL200 lamp which was redesigned into a more compact, lighter and slimmer shape, and fits any standard incandescent bulb socket. This 18 watt-lamp is claimed to have comparable lumens quality as the 75-watt incandescent bulb and lasts eight times longer. The retail price has been reduced from P395 to P295. Philips estimates that if 5% of the eligible market would shift to the SL200, annual savings of 57 GWH may be expected (PDI, 1993).

NPC's Research and Development Department completed a study on the "Possible Savings and Advantages due to Replacement of Household Incandescent Lighting with Fluorescent Lighting" in November 1990. The study estimated energy savings at approximately 1.74 GWH per year. The equivalent avoided capacity from a gas turbine plant amounts to 1000 MW, with a benefit-cost ratio of 1.15 (NPC, 1990). The results of the study were submitted to the Office of Energy Affairs in February 1991, requesting validation of the study and recommending consideration of subsidizing the cost of fluorescent bulbs and/or removing the import duty, if found warranted.

The Fuel and Appliance Testing Laboratory (FATL) under the Department of Energy started in July 1993 a CFL lighting efficiency study wherein the performance of all CFL brands will be tested. The study also involves the conduct of market research, in coordination with MERALCO. Last year, FATL conducted some tests on one CFL brand. Preliminary findings indicated sensitivity to voltage fluctuations.

The then Office of Energy Affairs (OEA) and the Department of Trade and Industry (DTI) launched an energy conservation program starting in July 1992. In cooperation with the Association of Home Appliance Manufacturers (AHAM), the OEA, consumer groups, and professional organizations, the Bureau of Product Standards (BPS) earlier formulated energy efficiency standards for room air-conditioners (PNS 396). A standard energy efficiency rating (EER) of 7.9 has been set for units with a cooling capacity below 12,000 kilojoules per hour (kj/hr) and 7.4 for units with over 12,000 kj/hr.

PNS 396 requires all manufacturers and importers of window-type air-conditioners to comply with these standards. A recent survey of air-conditioners in one of the leading department stores revealed that the EER label appeared on only one brand so far. The energy labelling program for room air-conditioners will be launched formally on 5 October 1993 in Metro Manila and in December in Cebu.

The cooperation of industry and private associations in the establishment of mandatory energy guides is a must. The Business World reports that a study by the George Washington University concluded that the mandatory energy guide in the US increased recognition of energy use. It was found that one third of washer buyers and one half of refrigerator buyers felt that the labels did affect their purchase decision. Moreover, label awareness had a highly significant and positive relationship with reported awareness of annual energy costs (1992).

Between November 1990 and April 1992, the FATL tested 17 air-conditioners of various sizes and models. Of the nine models with cooling capacity over 12,000 kj/hr, only four passed the EER standard of 7.4 Nevertheless, the average EER for all nine was 7.64. Of the eight models with cooling capacity below 12,000 kj/hr, five passed the EER standard of 7.9, with an average EER of 8.35. All eight models had an average EER of 8.125. These results indicate that there is potential for further increasing the standard, in due time. Eventually, with enhanced awareness, consumers will prefer high-efficiency appliances. Manufacturers will thus have to respond to the change in consumer preferences.

Eventually, the program is expected to be applied to appliances such as freezers and refrigerators. However, due to budget limitations, FATL cannot pursue testing of these appliances in the near future unless outside support is provided. The BPS has already formulated PNS 185:1989 (Method of Determining the Energy Consumption, Freezer Temperature and Energy Efficiency Factor of Refrigerators and Freezers for Household Use) and PNS 186:1989 (Performance Test Procedures for Refrigerators and Freezers for Households). Actual testing of refrigerator and freezer samples still has to be conducted prior to the establishment of standards.

MERALCO is also active in campaigning for energy conservation in households. MERALCO has been distributing leaflets containing conservation tips for lighting, cooking, TV viewing, electric fan, ironing clothes, refrigerator, air conditioning , and water pumps. The leaflets also contain information on how to read the electric meter, and average power consumption of household appliances.

Through the initiative of the then OEA and in cooperation with the National Engineering Center of the University of the Philippines, courses in basic energy management, energy audit, efficient operation of energy conserving equipment, and energy conservation technologies are also being conducted. At least five courses are offered each year, three in Metro Manila and one each in the Visayas and Mindanao.

The OEA also launched in 1989 a program to institutionalize energy management as a course in the engineering curricula. The University of Mindanao (UM) offers Energy Conservation and Resource Management as a pilot course. Engineering students at the undergraduate and post-graduate levels of the UM are also involved in practicum sessions with the DOE.

BENEFITS OF ENERGY CONSERVATION

Methodology

To assess the benefits of energy conservation, the cost of conserved energy (CCE) will be calculated as the cost of buying the conserved energy, using the following formula:

CCE = capital recovery factor* (investment/annual savings).

Taking into account the time value of money, a discount rate of 15% is used for subsidizing consumers of MERALCO and for the economic analysis. For subsidized consumers, who normally attach more value to present flows, a discount rate of 30% is assumed. From the NPC perspective, a discount rate of 10% is used.

The CCE is then compared with retail power tariffs and the long-run marginal cost of electricity generation from ERB's Energy Pricing and Regulatory Policy Study (International Development Planners et al, 1992), to determine the net benefit to the consumers, NPC and the economy.

The analysis will start from the consumer's perspective. Any consumer savings in electricity will be adjusted to account for transmission and distribution losses as well as reserve margin to calculate the avoided equivalent power generation from the utility's perspective. We assume that NPC's transmission loss amounts to 4% while MERALCO's transmission and distribution loss is 14%. Reserve margin is assumed at 15%.

In estimating avoided capacity, data on load factors for lighting, refrigerators and airconditioners are required. In the absence of these data, load factors were assumed to be the same as in the HEC study for Thailand. Then, avoided capacity was calculated using the following formula:

$$\text{Load factor} = \frac{\text{Annual Energy Savings}}{\text{Average Demand Reduction} * 8760 \text{ hours.}}$$

Considering that energy conservation measures are environmental-friendly, the analysis should also have imputed environmental credit for these measures, relative to conventional power supply development. (The Thai DSM program recommends a 15% environmental credit.) As will be seen later, even without this credit, energy conservation is less expensive than installing additional power capacity.

In parallel, the standard measures of profitability such as internal rate of return, net present value and payback periods will also be calculated.

Cost-Benefit Analysis

Lighting

CFLs, such as those of Philips, Hitachi, National Panasonic and Chiyoda, are widely available in retail stores in the Philippines. All CFL brands are imported, except for Philip's. CFLS are priced from P295 to P490 and last 6 to 8 times longer than incandescent lamps. The Osram brand is priced at around P140 , but requires an adaptor as it does not fit into incandescent lamp sockets.

A 16-watt CFL is equivalent to a 60-watt incandescent lamp while an 18-watt CFL is equivalent to a 75-watt incandescent lamp. Various combinations of these features are used in the analysis. The cost of lamps is also varied based on a reduction of the import duty on CFLs from 40% to 30%, 20% and 10%. Under the revised tariff and customs code of 1991, the import duty of CFLs (9405) shall be reduced from 45% in 1992 to 40% in 1993, 35% in 1994, and 30% in 1995 onwards. In comparison, incandescent lamps (8539.22) and ordinary fluorescent lamps (8539.31) are levied a tariff rate of 30%.

The base case used in the analysis is defined below:

	CFL	Incandescent
Retail Price (P)	295	20
Wattage (w)	18	75
Life (hours)	8000	1000
Average use per day (hours)	4	4

Subsidizing consumers of MERALCO will find shifting to CFLs more attractive than subsidized consumers would (see Table 7). As subsidized consumers place a higher value on present consumption, the net benefit to them, as well as the NPV, will be lower. In the case of NPC, paying for CFLs will generate a 40% IRR, much higher than they would earn if conventional energy capacity is installed. From the economic point of view, a CFL lighting program is also very attractive.

Assuming that all households in Metro Manila replace, on the average, two incandescent lamps with CFLs, the total avoided power capacity is 372 MW, costing US$203 million. (See Appendix 1).

Table 7. Cost-Benefit Analysis of Efficient Lighting

	Subsidizing	Subsidized	NPC	Economic
Cons. Savings (P/yr)	267.18	124.83		
CCE (P/kWh)	0.93	1.30	10.61	0.41
Net Benefit ((P/kWh)	2.28	0.20	1.26	0.65
Payback (years)	1.0	2.2	2.3	1.4
IRR (%)	103	44	40	77
NPV (P)	575	63	194	277

For subsidized consumers, the net benefit will increase to P0.50/kWh if the import duty of CFLs is reduced to 10%. However, if CFLs last only six times longer than incandescent lamps, the net benefit to subsidize consumers will be negative. (See Appendix 2 for results of sensitivity analysis). The claim on the life expectancy of CFLs should thus be substantiated through testing by the FATL.

NPC's IRR will increase to 60% if the tariff rate is 10%. Imposing a tariff duty of 30% at par with incandescent lamps will also raise the economic IRR to 86%.

Airconditioning

Concepcion Industries, Inc. (CII) is now marketing Condura and Carrier airconditioners which are claimed to be energy-efficient. The energy efficiency ratings (EER) of the Carrier models are claimed to range from 8.3 to 9.95 while Condura models have an EER of 10. Ongoing testing by the Fuels and Appliance Testing Laboratory will verify these claims. A standard test procedure is necessary to ensure comparability across various sizes and models.

CII studies show that airconditioning account for 935 MW an hour. They estimate that 29% of power demand last summer can be attributed to airconditioning. It is claimed that with an improvement in the EER to at least 9.0, power capacity of 175 to 225 MW can be saved (Business World, 1992).

The base cases for this study are defined below:

	Efficient	Current
< 12000 kj/hr		
Retail Price (P), 10% diff.	15950	14500
Wattage (w)	1420	1420
EER, 15% differential	9.1	7.9
Life (hours)	21900	21900
Average use per day (hours)	10	10
> 12000 kj/hr		
Retail Price (P), 10% diff.	17600	16000
Wattage (w)	2250	2250
EER, 15% differential	8.5	7.4
Life (hours)	21900	21900
Average use per day (hours)	10	10

The EERs of 7.4 and 7.9 above are the PNS standards. FATL tests have shown that there are some models which have surpassed these standards. For this analysis, at least a 15% improvement in efficiency is assumed. Once local manufacturers have retooled their equipment and improved their technologies, the government should raise the standards to further increase efficiency gains.

Table 8 shows that the use of a more efficient model will be viable both from the financial and economic points of view. All indicators point to better returns for larger airconditioners. Assuming that households consuming more than 700 KWH per month (49,376 which approximate the average annual sales of airconditioners from 1988 to 1992 of 49,147 units) can afford to buy new highly-efficient airconditioners, 19 to 41 MW of power capacity per year will be avoided. The equivalent foregone investment ranges from US$22 million to US$48 million (See Appendix 3).

Sensitivity tests also reveal that increasing the EER differential to 20%, will be more favorable, even if the price differential is increased to 15% (see Appendix 4).

Table 8. Cost-Benefit Analysis of Efficient Airconditioner

	Subsidizing	NPC	Economic
< 12000kj/hr			
Cons. Savings (P/yr)	295.99		
CCE (P/kWh)	0.49	0.32	0.20
Net Benefit (P/kWh)	2.72	1.55	0.68
Payback (years)	0.58	1.58	0.87
IRR (%)	172	62	115
NPV (P)	9342	3236	3888
> 12000kj/hr			
Cons. Savings (P/yr)	3955		
CCE (P/kWh)	0.34	0.22	0.14
Net Benefit (P/kWh)	2.87	1.65	0.75
Payback (years)	0.40	1.10	0.60
IRR (%)	247	90	165
NPV (P)	15501	5824	6544

Refrigerators

Refrigerator brands in the market include National, GE, Winner, Westinghouse, Kelvinator, Condura, and Sansio. Sathaye's investigations show that current models are inefficient compared to those available from the parent companies of local manufacturers. Sathaye also reveals that some brands claim 30% more energy efficient models but provide no information on the wattage or the electricity consumption. Only Philacor has a testing room which is used to test refrigerators for export to the United States (191).

Based on HEC studies, the average consumption of 400-500 kWh/year of an average refrigerator (4-6 cubic foot can be reduced by 50% by increasing the thickness of cabinet insulation from 3.5 cm to 7.5 cm. Additional gains can be made by improving compressor efficiency. HEC also suggests that the retail price of the improved model should be within 10 to 15% of current models, (HEC, 1991).

In the Philippines, although standard test procedures have already been developed, the FATL has not yet conducted any test of refrigerators. Thus, the claim of some manufacturers as regards energy efficiency cannot be verified as yet. The base cases are defined below:

	Efficient	Current
5 cu ft., 1 door, manual		
Retail Price (P), 10% diff.	8250	7500
Wattage (w)	80	80
Energy Efficiency	+50%	
Life (hours)	65700	65700
Average use per day (hours)	14	14
7 cu. ft., 1-door, manual		
Retail (P), 10% diff.	9350	8500
Wattage (w)	120	120
Energy Efficiency	+50%	
Life (hours)	65700	65700
Average use per day (hours)	14	14

Table 9 indicates that from the consumers' NPC's and economic points of view, the use of more efficient refrigerators present attractive energy savings. Given an average annual sales (1988-1992) of 235,629 units, between 24 to 37 MW of power capacity per year will be voided, amounting to US$28 million to US$43 mullion (see Appendix 5). However, if the price differential between current and efficient models of 5 cu-ft. refrigerators is raised to 15%, the net benefit to subsidized consumers and their NPVs will be negative. (See Appendix 6).

Table 9. Cost-Benefit Analysis of Efficient Refrigerators

	Subsidizing	Subsidized	NPC	Economic
5 cuft., 1-door, manual				
Cons. Savings (P/yr)	656	307		
CCE (P/kWh)	0.66	1.14	0.39	0.27
Net Benefit (P/kWh)	2.55	0.36	1.48	0.62
Payback (years)	1.44	2.45	3.09	1.70
IRR (%)	87	37	27	57
NPV (P)	2087	128	488	826
7 cu. ft., 1-door, manual				
Cons. Savings (P/yr)	984	460		
CCE (P/kWh)	0.50	0.86	0.30	0.20
Net Benefit (P/kWh)	2.71	0.64	1.58	0.69
Payback (years)	0.86	1.85	2.34	1.29
IRR (%)	115	52	39	77
NPV (P)	3406	467	1004	1386

OVERALL IMPACT OF EFFICIENCY IMPROVEMENTS IN RESIDENTIAL LIGHTING, REFRIGERATION AND AIRCONDITIONING

By the year 2000, replacement of incandescent lamps and the purchase of more efficient airconditioning and refrigerator units will save at least 575 MW to 918 MW in power capacity. Thus, capital investment requirements of at least US$500-US$840 million can be diverted to other priority development programs.

The equivalent reduction in pollutants emission will be very significant. For comparison, a 300-MW coal plant emits around 1,373 mg/standard cu.m. of SO_2 and 235 mg/standard cu.m. of NO_2. On the other hand, a gas turbine plant is estimated to emit 624 mg/standard cu.m. of SO_2 and 102 mg/standard cu.m. of NO_2.

CONCLUSIONS AND RECOMMENDATIONS

The foregoing clearly supports the general observation that the cost of conserved energy is far less than the cost of installing additional power capacity. An intensified and sustained nationwide energy conservation program can significantly reduce required capital investment for power development. Thus, the government can redirect funds towards social and other priority projects. Energy conservation also addresses the growing environmental issue while lowering energy imports and thus improving the balance of payments position. From the households point of view, net electricity cost savings can lead to better standards of living.

While the government, in coordination with the private sector, has made some progress in energy conservation, this is not the time for complacency. The gains achieved from earlier efforts can only be sustained and advanced with the synchronization of various efforts from both the legislative and executive branches of government. The support of the private sector, covering the utilities, media, non-government organizations, and consumers, is also imperative. The government is urged to consider the following recommendations for immediate action:

1. *Implementation of power tariff restructuring.* This recommendation is the single most effective factor in promoting energy conservation. By providing the right pricing signals, consumers will be encouraged to orient their purchasing decisions towards energy-efficient appliances and technologies and to alter their power consumption behavior.

2. *Institutionalization of an energy conservation program.* The passage of the proposed Energy Conservation Law is strongly endorsed. The Department of Energy should lead the formulation of a DSM master plan similar to the Thai program. The following fund sources may be considered for the program: official development assistance; funds from the Technology Transfer for Energy Management (TTEM) project that have been plowed into national treasury after the completion of the project; and the Oil Price Stabilization Fund.

3. *Formulation and implementation of standards for all appliances and energy-saving devices as well as building standards.* The formulation of reasonable standards should be preceded by actual testing of appliances. Adherence to standards will not only reduce capital investment requirements for additional power capacity but will also protect

consumers from unfair claims by manufacturers and importers. Financial support to the FATL is necessary to implement proposed testing programs that have been shelved due to funding constraints. The standards should also be reviewed and updated regularly to take into account worldwide technology improvements . In the construction of new homes, the use of energy-efficient technologies such as CFLs and wall and ceiling insultations should be promoted.

4. *Improvement in technical efficiency in the power transmission and distribution system.* The Energy Regulatory Board should enforce the implementation of technical standards to ensure reliability of power supply. It was noted earlier that CFLs are very sensitive to voltage fluctuations. A CFL program may not be viable in areas which suffer from erratic voltage fluctuations.

5. *Rationalization of tariff system to promote energy-efficient technologies.* The disparity in the tariff rates between CFLs and incandescent lamps should be corrected immediately. Revenue losses from a reduction in the tariff rate of CFLs will be adequately compensated by reduced capital expenditures for power development.

6. *Development of an energy technology information system.* Potential end users of energy-saving devices shun new technology unless proven to be cost-effective and reliable. Demonstration projects have to some degree relieved these apprehensions. The development of an energy technology information system should be supported and the dissemination of information to energy consumers and energy service industries about the range of available technologies should be accelerated. The Department of Energy and the Philippine Council for Industry and Energy Research and Development (PCIERD) are in the best position to spearhead this activity.

7. *.Raising energy-consciousness through training and education.* As provided in the Energy Plan, training and education will continue to be implemented in an effort to promote efficient energy use in various energy-intensive applications. Replication of the pilot program introducing energy management in the engineering curriculum should now be evaluated and pursued. Special topics on energy conservation may also be introduced even in primary and secondary schools.

REFERENCES

Bureau of Product Standards (1992). Household Appliances - Room Airconditioners: Energy Efficiency Standard and Labelling Requirements (unpublished material).

Barreiro, J. (21 August 1992). New generation Condura hits market next month. Business World.

Business World (28 July 1992). Government sets energy conservation program.

Center for Building Science (1990). New energy technology for the 21st Century: Compact fluorescent lamps (CFLs). Energy Efficiency Note, April, no. 2.

ESCAP-APCTT (1992). Integrating energy conservation and industrial development policies with special reference to Asia and the Pacific. Tech. Monitor: Your Technology Window to Asia and the Pacific, May-June 1992.

Geberer, R. (1987). Users cash in on rebate programs. In Energy User News Magazine, June 1987

HEC (1991). Demand side management for Thailand's electric power system: Five-year master plan. Submitted to Electricity Generating Authority of Thailand, Metropolitan Electricity Authority, and Provincial Electricity Authority.

HEC (1992). HEC Receives GEF Contract for Thailand. E-Notes, vol. 2, no. 3, July 1992.

International Development Planners, Kennedy & Donkin Power Ltd., and Resource Management International, Inc. (1992). Energy Pricing and Regulatory Policy Study. Prepared for the Energy Regulatory Board under the World Bank Energy Sector Loan, Manila, Philippines.

MacInnis, R. (1987). PL test results: It's time to change your bulbs. In Energy User News Magazine, November, 1987.

Mills, E. Persson, A., and Strahl, J. (1990). The inception and proliferation of European residential lighting efficiency programs. Proceedings of the ACEEE 1990 Summer Study on Energy Efficiency in Buildings. August 26 to September 1, 1990, Asilomar, California.

Munasinghe, M. (1990). Energy analysis and policy: Selected Works, London, Butterworths.

NPC (1990). Report on possible savings and advantages due to replacement of household incandescent lighting with flourescent lighting. NPC Research and Development Department, System Instrumentation and Control Division.

Office of Energy Affairs (1991). FINESSE country market study: Philippines. Paper presented during the FINESSE Workshop, 21-25 October 1991, Kuala Lumpur, Malaysia. Asian and Pacific Development Centre and the Pacific Development Centre and the World Bank.

Office of Energy Affairs (1992). Philippine energy plan: 1991-2000. Manila, Philippines.

Philippine Daily Inquirer (27 July 1993). Energy-saving flourescent lamp now in the market.

Sathaye (1991). Analysis and recommendations for a household electricity strategy. (Unpublished preliminary report).

World Bank (1990). Capital expenditures for electric power in developing countries. Energy Series Paper, no. 21, World Bank Industry and Energy Department, Washington, D.C.

Appendix 1. Cost-Benefit Analysis Efficient Lighting

Updated: July 1993 (Using ERB's LRMC computations)

	CFL	Incandescent	Difference
First (P)	295	20	275
Wattage (w)	18	75	57
Life (hours)	8,000	1,000	
Average Use/Day (hours)	4	4	

	Financial Cost			Economic
	Subsidizing	Subsidized	NPC	Cost
Electricity Saved (kwh/yr)	83.22	83.22	110.68	110.68
First Cost/Elec. Saved (P/kwh)	3.30	3.30	2.48	1.47
Discount Rate	15%	30%	10%	15%
Capital Recovery Factor	0.28	0.39	0.25	0.28
Cost of Conserved Energy (CCE, P/kwh)	0.93	1.30	0.61	0.41
Tariff (P/kwh)	3.21	1.50	1.87	1.06
Energy charge (P/kwh)				1.04
Capacity charge (P/kw/month)				380.9
Net Benefit: Tariff - CCE (P/kwh)	2.28	0.20	1.26	0.65
Consumer Elec. Savings (P/yr)	267.18	124.83		
Simple payback (years)	1.0	2.2	2.3	1.4
IRR	103%	44%	40%	77%
NPV (P)	575	63	194	277
Avoided capacity per lamp (w)			74	
Avoided capacity per HH (w)			149	
Total avoided capacity (MW)			372	
Cost of avoided capacity (US$ million)			203	

Notes/Assumptions:

NPC transmission loss	4%
MERALCO T&D loss	14%
Reserve margin	15%
Investment cost of gas turbine	546 US$/kw (Energy Plan)
Exchange rate	2P/US$
Load factor	17%
Electrified HH in MERALCO's area	2.5 million as of December 1992
Number of incandescent lamps/HH	2
Import duty on CFLs for 1993	40%
Import duty on incandescent lamps	30%

LRMC tariff charges based on gas turbine as peaking plant.

Appendix 2. Results of Sensitivity Analysis for Efficient Lighting

	CCE (P/kwh)	Net Bene-fit(P/kwh)	Payback (years)	IRR (%)	NPV (P)	Savings (P/yr)	Avoided MW/yr
P295 18w¯75w 8000 hrs							372
Subsidizing	0.93	2.28	1.03	103	575	267	
Subsidized	1.30	0.20	2.20	44	63	125	
NPC	0.61	1.26	2.34	40	194		
Economic	0.41	0.65	1.39	77	277		
P274 18w¯75w 8000 hrs							372
Subsidizing	0.86	2.35	0.95	113	596	267	
Subsidized	1.20	0.30	2.03	49	84	125	
NPC	0.56	1.31	2.16	46	215		
Economic	0.38	0.68	1.28	86	290		
P253 18w¯75w 8000 hrs							372
Subsidizing	0.78	2.43	0.87	124	617	267	
Subsidized	1.10	0.40	1.87	56	105	125	
NPC	0.52	1.36	1.98	52	236		
Economic	0.35	0.71	1.17	95	302		
P231 18w¯75w 8000 hrs							372
Subsidizing	0.71	2.50	0.79	138	639	267	
Subsidized	1.00	0.50	1.69	64	127	125	
NPC	0.47	1.40	1.80	60	258		
Economic	0.32	0.75	1.06	107	315		
P295 18w¯60w 8000 hrs							274
Subsidizing	1.26	1.95	1.40	74	375	197	
Subsidized	1.76	(0.26)	2.99	28	(8)	92	
NPC	0.83	1.04	3.18	26	96		
Economic	0.56	0.50	1.88	55	179		
P274 18w¯60w 8000 hrs							274
Subsidizing	1.16	2.05	1.29	82	396	197	
Subsidized	1.63	(0.13)	2.76	33	13	92	
NPC	0.77	1.11	2.93	30	117		
Economic	0.52	0.54	1.74	62	192		
P253 18w¯60w 8000 hrs							274
Subsidizing	1.07	2.15	1.18	91	417	197	
Subsidized	1.49	0.01	2.53	39	34	92	
NPC	0.70	1.17	2.69	36	138		
Economic	0.47	0.59	1.59	70	204		
P231 18w¯60w 8000 hrs							274
Subsidizing	0.96	2.25	1.07	103	439	197	
Subsidized	1.35	0.15	2.29	46	56	92	
NPC	0.64	1.24	2.44	42	160		
Economic	0.43	0.63	1.44	79	217		
P295 18w¯60w 6000 hrs							274
Subsidizing	1.54	1.67	1.40	74	375	197	
Subsidized	2.04	(0.54)	2.99	28	(8)	92	
NPC	1.04	0.83	3.18	26	96		
Economic	0.69	0.38	1.88	55	179		
P274 18w¯60w 6000 hrs							274
Subsidizing	1.42	1.79	1.29	82	396	197	
subsidized	1.88	(0.38)	2.76	33	13	92	
NPC	0.96	0.91	2.93	30	117		
Economic	0.63	0.43	1.74	62	192		
P253 18w¯60w 6000 hrs							274
Subsidizing	1.30	1.91	1.18	91	417	197	
Subsidized	1.73	(0.23)	2.53	39	34	92	
NPC	0.88	0.99	2.69	36	138		
Economic	0.58	0.48	1.59	70	204		
P231 18w¯60w 6000 hrs							274
Subsidizing	1.18	2.03	1.07	103	439	197	
Subsidized	1.56	(0.06)	2.29	46	56	92	
NPC	0.80	1.08	2.44	42	160		
Economic	0.52	0.54	1.44	79	217		

Appendix 3. Cost-Benefit Analysis of Efficient Airconditioners

Updated: July 1993 (Using ERB's LRMC computations)

1 HP ˉ <12,000 kj/hr	Efficient	Current	Difference
First Cost (P)	15,950	14,500	1,450
EER	9.1	7.9	15.0%
Wattage (w)	1,420	1,420	
Life (hours)	21,900	21,900	
Average Use/Day (hours)	10	10	

	Financial Cost		Economic
	Subsidizing	NPC	Cost
Electricity Saved (kwh/yr)	777.45	1,034.01	1,034.01
First Cost/Elec Saved (P/kwh)	1.87	1.40	0.77
Discount Rate	15%	10%	15%
Capital Recovery Factor	0.26	0.23	0.26
Cost of Conserved Energy (CCE, P/kwh)	0.49	0.32	0.20
Tariff (P/kwh)	3.21	1.87	0.89
Energy charge (P/kwh)			0.89
Capacity charge (P/kwh/month)			380.90
Net Benefit: Tariff - CCE (P/kwh)	2.72	1.55	0.68
Consumer Elec. Savings (P/yr)	2,495.99		
Simple payback (years)	0.58	1.58	0.87
IRR	172%	62%	115%
NPV (P)	9,342	3,236	3,888

Avoided capacity per aircon (w)	393	
Avoided capacity per HH (w)	393	
Total avoided capacity (MW)	19	
Cost of avoided capacity (US$ million)	23	

Notes/Assumptions:

NPC transmission loss	4%	
MERALCO T&D loss	14%	
Reserve margin	15%	
Investment cost of gas turbine	546 US$/kw	(Energy Plan)
Investment cost of coal plant	1336 US$/kw	(Energy Plan)
Exchange rate	27 P/US$	
Load factor	30%	
Number of HH consuming more than 700 kWh/mo.	49376 as of March 1993	
Number of aircons/HH	1	
Import duty on window-type aircons	45%	
LRMC energy charge based on: P/kwh 1.04	20% peak	
P/kwh 0.85	80% off-peak	
Price differential between efficient and current	10%	

Appendix 4. Results of Sensitivity Analysis for Efficient Airconditioners

	CCE (P/kwh)	Net Benefit (P/kwh)	Payback (years)	IRR (%)	NPV (P)	Savings (P/kwh)	Avoided MW/yr
<12,000 kj/hr, P14500 10% price diff EER: 7.9 vs. 9.1 (15% differential)							19
Subsidizing	0.49	2.72	0.58	172	9,342	2,496	
NPC	0.32	1.55	1.58	62	3,236		
Economic	0.20	0.68	.87	115	3,888		
<12,000 kj/hr. P14500 15% price diff EER: 7.9 vs. 9.1 (15% differential)							19
Subsidizing	0.74	2.47	0.87	114	8,617	2,496	
NPC	0.48	1.39	2.37	39	2,511		
Economic	0.31	0.58	1.30	76	3,490		
<12,000 kj/hr, P14500 15% price diff EER:7.9 vs. 9.5 (20% differential)							26
Subsidizing	0.55	2.66	0.65	153	12,215	3,328	
NPC	0.36	1.51	1.78	54	4,073		
Economic	0.23	0.66	0.98	102	5,051		
<12,000 kj/hr, P14500 10% price diff EER:7.9 vs. 9.5 (20% differential)							26
Subsidizing	0.37	2.84	0.44	229	12,940	3,328	
NPC	0.24	1.63	1.18	84	4,798		
Economic	0.15	0.74	0.65	153	5,450		
>12,000 kj/hr, P16000 10% price diff EER:7.4 vs. 8.5 (15% differential)							31
Subsidizing	0.34	2.87	0.40	247	15,501	3,955	
NPC	0.22	1.65	1.10	90	5,824		
Economic	0.44	0.75	0.60	165	6,544		
>12,000 kj/hr P16000 15% price diff EER: 7.4 vs. 8.5 (15% differential)							31
Subsidizing	0.51	2.70	0.61	165	14,701	3,955	
NPC	0.34	1.54	1.65	59	5,024		
Economic	0.21	0.68	0.91	110	6,104		
>12,000 kj/hr, P16000 15% price diff EER: 7.4 vs. 8.9 (20% differential)							41
Subsidizing	0.39	2.82	0.46	220	20,401	5,273	
NPC	0.25	1.62	1.24	80	7,498		
Economic	0.16	0.73	0.68	147	8,578		
>12000 kj/hr , P16000, 10% price diff EER: 7.4 vs. 8.9 (20% differential)							41
Subsidizing	0.26	2.95	0.30	330	21,201	5,273	
NPC	0.17	1.71	0.82	121	8,298		

Appendix 5. Cost-Benefit Analysis of Efficient Refrigerators

Updated: July 1993 (Using ERB's LRMC computations)

Single Door,Manual,5 cu.ft.	Efficient	Current	Difference	
First Cost (P)	8,250	7,500	750	
Wattage (w)	80	80		
Energy Efficiency Improvement			50%	
Life (hours)	65,700	65,700		
Average Use/Day (hours)	14	14		
	Financial Cost			Economic
	Subsidizing	Subsidized	NPC	Cost
Electricity Saved (kwh/yr)	204.40	204.40	271.85	271.85
First Cost/Elec. Saved (P/kwh)	3.67	3.67	2.76	1.52
Discount Rate	15%	30%	10%	15%
Capital Recovery Factor	0.18	0.31	0.14	0.18
Cost of Conserved Energy (CCE P/kwh)	0.66	1.14	0.39	0.27
Tariff (P/kwh)	3.21	1.50	1.87	0.89
Energy charge (P/kwh)				0.89
Capacity charge (P/kwh/month)				380.90
Net Benefit: Tariff - CCE (P/kwh)	2.55	0.36	1.48	0.62
Consumer Elec. Savings (P/yr)	656.22	306.60		
Simple payback (years)	1.14	2.45	3.09	1.70
IRR	87%	37%	27%	57%
NPV (P)	2,087	128	488	826
Avoided capacity per refrigerator (w)			103	
Total avoided capacity (MW)			24	
Cost of total avoided capacity (US$ million)			29	

Notes:

NPC transmission loss			4%
MERALCO T&D loss			14%
Reserve margin			15%
Investment cost of gas turbine			546 US$/kw (Energy Plan)
Investment cost of coal plant			1336 US$/kw (Energy Plan)
Exchange rate			25 P/US$
Load Factor			30%
Average annual sales of refs (1988-1992)			235629
Import duty on refrigerators			45%
LRMC energy charge based on:	P/kwh	1.04	20% peak
	P/kwh	0.85	80% off-peak
Price differential between efficient and current			10%

Appendix 6. Results of Sensitivity Analysis for Efficient Refrigerators

	CCE (P/kwh)	Net Benefit (P/kwh)	Payback (years)	IRR (%)	NPV (P)	Savings P/kwh)	Avoided MW/yr
5 cu.ft.,P7500, 80w.10% price differential							
50% improvement in efficiency							24
Subsidizing	0.66	2.55	1.14	87	2,087	656	
Subsidized	1.14	0.36	2.45	37	128	307	
NPC	0.39	1.48	3.09	27	488		
Economic	0.27	0.62	1.70	57	826		
5 cu.ft., P7500,15% price differential							
50% improvement in efficiency							24
Subsidizing	0.99	2.22	1.71	56	1,712	656	
Subsidized	1.71	(0.21)	3.67	20	(247)	307	
NPC	0.59	1.29	4.64	13	113		
Economic	0.41	0.48	2.55	35	619		
7 cu.ft., P8500, 12w, 10% price differential							
50% improvement in efficiency							37
Subsidizing	0.50	2.71	0.86	115	3,406	984	
Subsidized	0.86	0.64	1.85	52	467	460	
NPC	0.30	1.58	2.34	39	1,004		
Economic	0.21	0.69	1.29	77	1,386		
7 cu.ft., P8500, 120w, 15% price differential							
50% improvement in efficiency							37
Subsidizing	0.75	2.46	1.30	76	2,981	984	
Subsidized	1.29	0.21	2.77	31	42	460	
NPC	0.44	1.43	3.51	22	579		
Economic	0.31	0.58	1.93	49	1,153		