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Concept Paper

Energy Efficiency Standards & Labeling for Appliances

Bhutan

Nexant

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CONCEPT PAPER

ENERGY EFFICIENCY STANDARDS AND LABELING FOR APPLIANCES IN BHUTAN

Prepared for

United States Agency for International Development

Under

South Asia Regional Initiative for Energy

Prepared by

NEXANT SARI/Energy

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Executive Summary

ENERGY AND ECONOMIC OUTLOOK

Bhutan has no commercially viable reserves of oil, natural gas or coal, and, hence, is dependent on imported fuels to fulfill the country's primary energy requirements. However, Bhutan has significant hydropower potential from its steep mountains, deep gorges, and fast-flowing rivers. The theoretical hydropower potential has been estimated at around 30,000 MW, of which **50%** is considered to be economically viable. Bhutan's hydropower development is assessed to have low environmental and ecological impacts because of the high potential for run-of-the-river schemes.

Since the completion of the Chukha hydropower plant, which was partially funded by the Indian government, Bhutan has been exporting surplus electricity to India. Electric power export has become a key source of revenue for the government. The revenue from electricity exports accounted for about **40%** of the total national income during the 8th Five Year Plan (FYP) for the period July 1997 to July 2002.

Financing power sector development continues to be a burden for the Government of Bhutan. Major hydropower projects, transmission grids, and urban and rural electrification have been delayed due to financial constraints. Moreover, deficiency of tools and technical capability to maintain the existing power system has compounded the problems in the power sector.

SCOPE OF THE CONCEPT PAPER

This concept paper aims to highlight to policymakers in Bhutan the importance of Energy Efficiency Standards and Labeling (EE S&L) as a tool for sustainable economic development within an energy sector development strategy. This report also presents information on the broad experiences of similar programs in Asia and Worldwide. The experience of EE S&L programs in many countries demonstrates substantial electricity peak demand reduction and energy savings with attractive cost/benefit ratios. This concept paper also identifies key appliances for EE S&L programs in Bhutan, including potential electricity peak demand reduction and energy saving.

APPROACH INVOLVED IN THE CONCEPT PAPER

Demand-side Management (DSM) studies conducted in several Asian countries generally have shown that the cost of saving a unit of energy through energy efficiency strategies is much less expensive than producing a unit of energy through a new power plant. This current study is designed to estimate the potential in Bhutan for energy savings at low cost through implementation of an effective EE S&L program for domestic appliances. This estimate is based on currently available data and information.

Energy standards involve a set of procedures that define the energy performance of manufactured products, sometimes prohibiting the sale of products where energy consumption is higher than the minimum standard. Energy labels, on the other hand, are the informative labels affixed to manufactured products in order to provide consumers with the data necessary for making informed purchases. An EE S&L program is a demand-side option that offers numerous potential benefits to Bhutan. These include reduction in electricity peak demand, increased energy security for sustainable economic development, and increased consumer awareness of energy and the environment.

In the absence of recent statistical data on appliances and electricity load profiles, the analysis in this concept paper was based on data gathering from literature researches, questionnaires and expert interviews. Estimates of potential efficiency improvements of domestic appliances based on overseas experience also were used in the analysis.

MAJOR FINDINGS

Industry is the largest consuming sector in Bhutan. However, the residential sector plays a more significant role in the variation of daily electricity demand due to the use of domestic appliances in the morning and in the evening. Home appliances such as lamps typically add 3 - 5 MW to evening electricity demand. During winter, appliances such as electrical room heaters account for an additional 4 - 8 MW in demand. It has been estimated that Bhutan imports over 300,000 lamps per annum, which are predominantly incandescent lamps.

Introduction of an EES&L program in Bhutan covering fluorescent lighting, rice cookers and refrigerators—complemented by a public awareness campaign to promote efficient appliances—could potentially save 5 - 8 MW electricity peak demand over a 5-year period. This peak demand savings corresponds to a generation capacity saving of 6 - 9 MW, or more than Nu. 180 million capital investment in new capacity. Exporting of this energy saving could also generate Nu. 12 million revenue over the 5-year period.

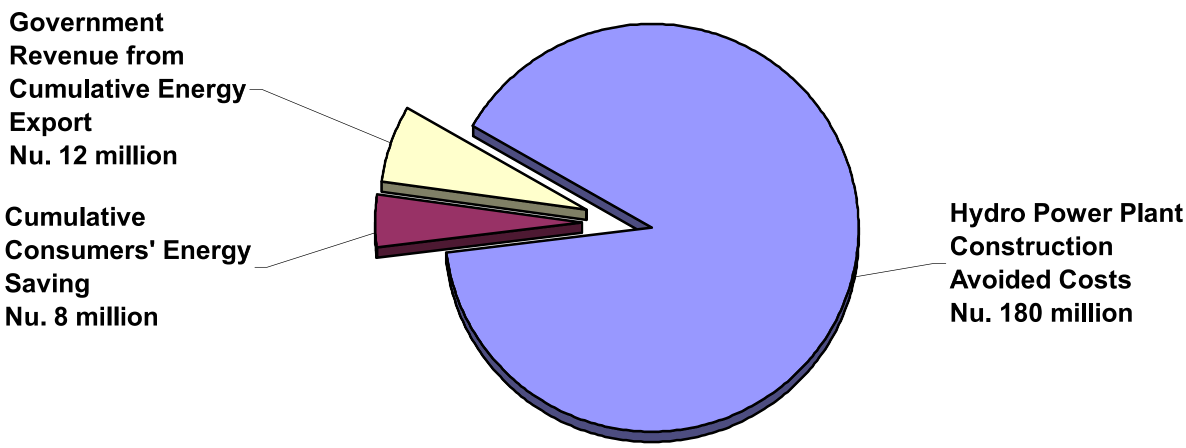
5-Year Standards and Labeling Program Potential	
Peak Demand Reduction:	5-8 MW
Generation Saving *(Peak Demand Reduction + 10% system loss):*	6-9 MW
Cost of 6 MW Hydro Power Plant *6 MW x Nu. 30 million/MW[1]):*	**Nu. 180 million**
Cumulative Consumers' Energy Saving:	12 GWh
5-Year Consumers' Energy Saving *(12 GWh x Nu. 0.70/kWh[2]):*	**Nu. 8 million**
Cumulative Energy Export Revenue *(12 GWh x Nu. 1.00/kWh[3]):*	**Nu. 12 million**
Total Standards and Labeling Financial Gain	**Nu. 200 million**
Total Standards and Labeling Financial Gain	**Nu. 200 million**

[1] Hydro Power Plant Construction Avoided Cost: Nu. 30 million/MW based on construction costs of Kurichu and Tala power plant

[2] Eighth Five Year Plan Mid-Term Review Report (July 1997 – December 1999), Planning Commission, Royal Government of Bhutan

[3] Eighth Five Year Plan Mid-Term Review Report (July 1997 – December 1999), Planning Commission, Royal Government of Bhutan

5-Year Standards and Labeling Program Potential



Total Potential Financial Gain: Nu. 200 million

CHALLENGES AHEAD

To achieve a successful EE S&L program, it would be necessary for the Government of Bhutan to focus on proper planning as well as initiating collaboration among relevant stakeholders. The absence of information on appliance saturation and end-use consumption in different segments of the residential sector is one of the key challenges that need addressing in the short term. Other challenges in pursuing the EE S&L concept include:

- Short-term and long-term funding to support EE S&L programs
- A legal framework to facilitate implementation of EE S&L programs
- Availability of local energy performance testing facilities

KEY RECOMMENDATIONS

To establish a sustainable S&L program, the following steps are recommended:

1. Establish a Steering Committee with the responsibility of setting energy efficiency standards and labeling for appliances. Such a committee should ideally be comprised of representatives from the following major stakeholders:

    - Planning Commission, Royal Government of Bhutan
    - Department of Trade, Ministry of Trade and Industry
    - Department of Power, Ministry of Trade and Industry
    - Department of Revenue and Customs, Ministry of Finance

2. Prepare a Plan of Action for the EE S&L program over a specified period.
3. Conduct a detailed feasibility study to include: market surveys on customer awareness and preferences; appliance saturation and usage profiles; scope of appliance efficiency gains; detailed cost/benefit analysis; institutional framework for S&L; and power system characteristics that are likely to impact on S&L.
4. Establish a mechanism to harmonize standard setting and labeling programs with ongoing programs in neighboring countries.

Section 1 Background

1.1 SARI/ENERGY

The South Asia Regional Initiative for Energy (SARI/Energy) promotes mutually beneficial energy linkages among the nations of South Asia. SARI/Energy is sponsored by the U. S. Agency for International Development (USAID). The first phase of the program began in 2000 and will end in 2003. Under the Energy Efficiency (EE) component, SARI/Energy has identified energy efficiency standards setting and labeling of end-use appliances as an important element to help meet the ever-increasing demand for electricity, which is a major challenge faced by all SARI member countries.

EE Standards and labeling of end-use appliances have proven to be effective tools to curb electricity demand in many countries. However, due to the poor penetration of EE appliances in most developing countries, there are a number of barriers to their implementation that need to be overcome, such as lack of awareness of the benefits of EE appliances, high initial cost of EE appliances, and the non-availability of EE appliances in the market.

Under the technical assistance component of the SARI/Energy Program, Nexant SARI/Energy is proposing to undertake a series of activities to promote Energy Efficiency Standards & Labeling of appliances in the region. The objectives of these activities are to:

- Assist the local standards institutions to understand the benefits from EE standards & labeling;
- Communicate the role and benefits from EE standards in competitive markets;
- Develop a mechanism and network for regional standards setting;
- Evaluate the benefits from regional testing facilities & recognize regional testing bodies for labeling to support EE standards and;
- Establish a monitoring process.

1.2 THE ENERGY STANDARDS AND LABELING CONCEPT PAPER

Bhutan has an opportunity to achieve significant energy savings at low cost by implementing energy standards and labeling strategies for a range of domestic appliances. However, there are several components of the program that need to be considered. To achieve a tangible result, a standards and labeling (S&L) program would require coordination and participation from various stakeholders, especially key support from the Government of Bhutan. This concept paper aims to inform policy makers on the importance of an EE S&L program and its potential benefits; the status of EE S&L programs worldwide, including case studies with cost and benefits; and identify key appliances for EE S&L programs in Bhutan, including potential benefits.

2.1 DEFINITIONS

Energy Standards and labeling programs have shown to be a cost-effective method to help countries cope with rapidly rising electricity consumption resulting from the proliferation of electrical appliances in the domestic sector. Energy standards are a set of procedures that define the energy performance of manufactured products, sometimes prohibiting the sale of products where energy consumption is higher than the minimum standard. The term “standard” commonly encompasses two possible elements:

1. A well-defined protocol (or laboratory test procedure) by which to obtain a sufficiently accurate estimation of the energy performance of a product in the way it is typically used, and;
2. A target limit on energy performance (usually a maximum use or minimum efficiency) formally established by an international agency, a widely recognized manufacturer association, or a government-based agency based upon a specified test standard. Minimum Energy Performance Standard (MEPS) is the common term for an energy standard that products must meet before they can be sold.

Energy labels, on the other hand, are the informative labels affixed to manufactured products in order to provide consumers with the data necessary for making informed purchases. They always serve as a complement to the energy standards. The energy labels indicate a product’s energy performance.

Figure 2-1: Endorsement Labels

Generally, energy labels are categorized into two broad categories; **Endorsement labels** and **Comparative labels**. Endorsement labels, as shown in Figure 2-1, are mostly of a voluntary nature and serve as the approval seals from government agencies or institutions. However, comparative labels can be both voluntary and mandatory in nature. The visual designs of comparative labels in use around the world, as shown in Figure 2-2, can be grouped into three basic types:

1. **Dial Type:** This type of label has a “dial” or gauge, with greater efficiency linked to advancement along the gauge (more efficient represented by a clockwise arc). This type of label is used in Australia, Thailand, and Korea and has been proposed for India.

2. **Bar Type:** This type of label uses a bar chart with a grading from best to worst. All grade bars are visible on every label with a marker next to the appropriate bar indicating the grade of the model. This label is used primarily in Europe and South America.

3. **Linear Type:** This label has a linear scale indicating the highest and lowest energy use of models on the market, locating the specific model within that scale. This model is used in North America

Also there are many other energy labels that have no graphic concept to support the indication of energy efficiency. These generally rely on text to explain the efficiency or some numeric indicator of efficiency. These labels are also called "Informative-Only Labels".

Figure 2-2: Comparative Labels (bar, linear, dial and informative-only)

2.2 POTENTIAL BENEFITS

Energy standards and labels can play an important role in sustainable development in developing countries. Energy efficiency improvements through S&L strategies can slow the growth in electricity demand, reduce capital expenses for energy infrastructure and also provide savings to electricity consumers. For most developing countries, financing energy sector expansion is a significant burden on the economy. It has been proven that the cost of saving 1 kWh of energy through energy-efficiency programs generally is much less expensive than producing 1 kWh of energy through a new power plant. Energy S&L also offers practical and cost-effective ways to meet both in-country and global environmental objectives. For countries reliant on imported fossil fuels for power generation, a decrease in electricity demand will save valuable foreign exchange, reduce local environmental impacts and conserve indigenous resources.

2.3 STATUS OF STANDARDS AND LABELING PROGRAMS WORLDWIDE

The status of energy S&L programs around the world and the types of equipment and appliances included vary from country to country. Figure 2-3 illustrates the effective years of energy efficiency S&L programs around the world. The most recent updates of Asian S&L programs are given in Table 2-1.

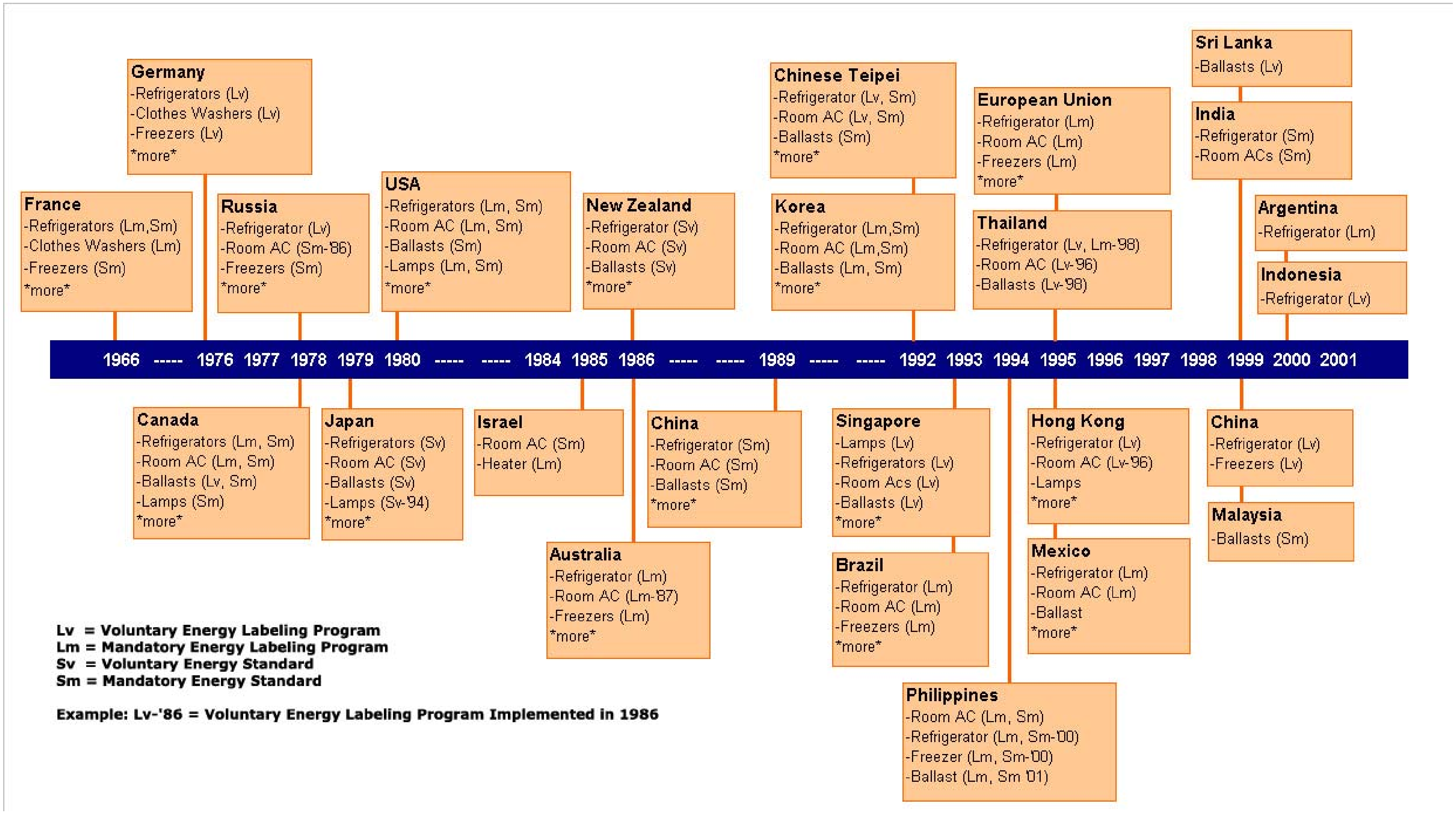

1966 ----- 1976 1977 1978 1979 1980 ----- ----- 1984 1985 1986 ----- ----- 1989 ----- ----- 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001
France
-Refrigerators (Lm,Sm)
-Clothes Washers (Lm)
-Freezers (Sm)
more
Germany
-Refrigerators (Lv)
-Clothes Washers (Lv)
-Freezers (Lv)
more
Russia
-Refrigerator (Lv)
-Room AC (Sm-'86)
-Freezers (Sm)
more
USA
-Refrigerators (Lm, Sm)
-Room AC (Lm, Sm)
-Ballasts (Sm)
-Lamps (Lm, Sm)
more
New Zealand
-Refrigerator (Sv)
-Room AC (Sv)
-Ballasts (Sv)
more
Chinese Teipei
-Refrigerator (Lv, Sm)
-Room AC (Lv, Sm)
-Ballasts (Sm)
more
Korea
-Refrigerator (Lm,Sm)
-Room AC (Lm,Sm)
-Ballasts (Lm, Sm)
more
European Union
-Refrigerator (Lm)
-Room AC (Lm)
-Freezers (Lm)
more
Thailand
-Refrigerator (Lv, Lm-'98)
-Room AC (Lv-'96)
-Ballasts (Lv-'98)
Sri Lanka
-Ballasts (Lv)
India
-Refrigerator (Sm)
-Room ACs (Sm)
Argentina
-Refrigerator (Lm)
Indonesia
-Refrigerator (Lv)
Canada
-Refrigerators (Lm, Sm)
-Room AC (Lm, Sm)
-Ballasts (Lv, Sm)
-Lamps (Sm)
more
Japan
-Refrigerators (Sv)
-Room AC (Sv)
-Ballasts (Sv)
-Lamps (Sv-'94)
more
Israel
-Room AC (Sm)
-Heater (Lm)
China
-Refrigerator (Sm)
-Room AC (Sm)
-Ballasts (Sm)
more
Australia
-Refrigerator (Lm)
-Room AC (Lm-'87)
-Freezers (Lm)
more
Singapore
-Lamps (Lv)
-Refrigerators (Lv)
-Room Acs (Lv)
-Ballasts (Lv)
more
Brazil
-Refrigerator (Lm)
-Room AC (Lm)
-Freezers (Lm)
more
Philippines
-Room AC (Lm, Sm)
-Refrigerator (Lm, Sm-'00)
-Freezer (Lm, Sm-'00)
-Ballast (Lm, Sm '01)
Hong Kong
-Refrigerator (Lv)
-Room AC (Lv-'96)
-Lamps
more
Mexico
-Refrigerator (Lm)
-Room AC (Lm)
-Ballast
more
China
-Refrigerator (Lv)
-Freezers (Lv)
Malaysia
-Ballasts (Sm)
Lv = Voluntary Energy Labeling Program
Lm = Mandatory Energy Labeling Program
Sv = Voluntary Energy Standard
Sm = Mandatory Energy Standard
Example: Lv-'86 = Voluntary Energy Labeling Program Implemented in 1986

Table 2-1: Recent Update of Asian Standards and Labeling Programs

Country	Energy Standards and Labeling Program	Remarks
India	Voluntary Energy Labeling	Products: Refrigerators and Freezers, label design was completed in late 1999. The Energy Conservation Bill to foster the development of Indian labeling program was approved by Government of India in 2001.
	Voluntary Minimum Energy Performance Standards	Products: Refrigerators and Freezers (1999)
Sri Lanka	Voluntary Energy Labeling	Products: Ballasts (1999) and CFLs (2001)
Thailand	Mandatory Energy Labeling	Product: Refrigerators (Voluntary in 1995 and Mandatory in 1998)
	Voluntary Energy Labeling	Products: Air-conditioners (1996), Ballasts (1998)
	Mandatory Minimum Energy Performance Standards	Products: Compact Fluorescent lamps, Fluorescent tubes, Ballasts, Refrigerators, Air-Conditioners, Motors (2004)

2.3.1 India

Currently, India's power system has a peak demand deficit of around **14.5%** and transmission and distribution losses of approximately **23%**. This is in part due to the rapidly growing demand in the residential sector. India does not have an established S&L program at this stage. However, since the passage of the Energy Conservation Bill in August 2001, S&L is one of the priority programs to be implemented through the newly established Bureau of Energy Efficiency (BEE).The Bill legally authorizes the issue of Minimum Energy Performance Standards (MEPS) and Labels for equipment and appliances. USAID collaborated with the Ministry of Power and the Bureau of Indian Standards (BIS) to research the design and effectiveness of the label. The label design process is an excellent example of how to develop a relevant national energy label and utilize considerable consumer and stakeholder input. A sample of the label design is given in Figure 2-4.

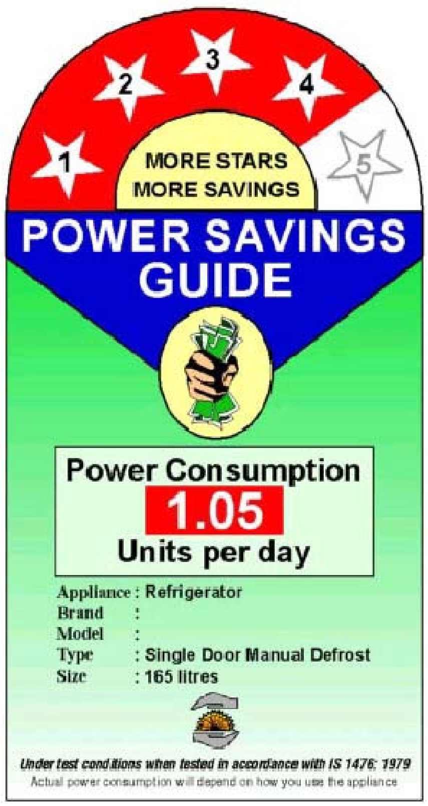


Figure 2-4: Indian Label Design

2.3.2 Sri Lanka

The Ceylon Electricity Board (CEB), in association with the Sri Lanka Standards Institute (SLSI), is currently implementing a ballast energy-labeling program on a voluntary basis. This ballast-labeling program targets suppliers and large commercial end-users. A sample of the label design is given in Figure 2-5. The National Engineering Research and Development Center (NERD) will test sample ballasts as per the Sri Lanka standards. Additional testing facilities to support refrigerators are under consideration, to be funded by the World Bank.

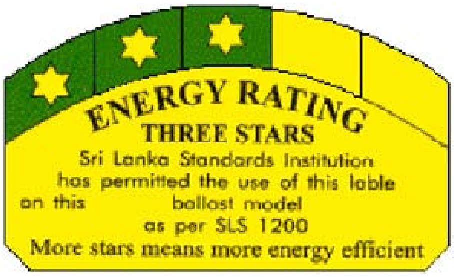


Figure 2-5: Sri Lanka Ballast Label

CEB also intends to seek further funding to cover testing facilities for other appliances, for example, air conditioners, motors, ceiling and table fans, and TVs. In addition to the ballast labeling program, CEB is also initiating a labeling program for Compact Fluorescent Lamps (CFLs).

2.3.3 Thailand

Following the success of the labeling programs for refrigerators, the Demand Side Management office (DSM) of the Electricity Generating Authority of Thailand (EGAT) reached an agreement with manufacturers to raise the efficiency categories on the label for single-door refrigerators by **20%**, effective January 2001. The success of the energy labeling program led the government to fund the development of Minimum Energy Performance Standards (MEPS) for six types of products, i.e. refrigerators, air conditioners, compact fluorescent lamps (CFLs), fluorescent tube lamps, ballasts and electric motors. The government is expected to adopt the proposed standards in 2004. A sample of the Thai refrigerator label is given in Figure 2-6.

Figure 2-6: Thai Revised Label, 2000

2.4 SUMMARY OF SUCCESS STORIES

S&L programs are unique to each country. Some countries have implemented only standards; others only energy labels, and some have implemented both. Table 2-2 provides a summary of the achievements for a sample of countries.

Table 2-2: Summary of Successful Programs and Achievements

Country or Region	Program	Actual Results
Australia	Mandatory Standards and Labels	▪ **11%** reduction in energy consumption of labeled appliances (1992) ▪ Approximately equal to 630 GWh of saved energy or **1.6%** decrease in total household electricity consumption (1992) ▪ Estimated **12%** and **6%** lower electricity consumption of refrigerators and air conditioners respectively ▪ **14 - 33%** further reduction in refrigerator energy consumption with MEPS introduction
European Union	Mandatory Standards and Labels	▪ The average efficiency of the cold-appliance market has improved by approximately **27%** since the introduction of labels and MEPS. (1990/1992-1999) ▪ **6%** improvement on annual energy efficiency of refrigerators and freezers (1990/1992-1994) and an additional **4.5%** from 1994 to 1996 (only energy labeling program)
Korea	Mandatory Standards and Labels	▪ **39%**improvement in fluorescent lamp efficiency (1993-2000) ▪ **74%** decrease in refrigerator energy consumption (1993-2000) ▪ **54%** improvement in air-conditioner efficiency (1993-2000)
Philippines	Mandatory Standards and Labels	▪ **23%** improvement in energy consumption of all air conditioner units between 1992 and 1997 ▪ Energy Savings: 6 MW in demand and 17GWh in consumption (after first year)
Thailand	Voluntary Labels	▪ **12%** decrease in refrigerator energy consumption (1995-1999) ▪ Energy Savings: 168 MW in demand and 1,167 GWh in consumption. (As of June 2000)

Note: Details of successful programs are given in Appendix A.

Bhutan has no commercially feasible oil or gas resources and hence is dependent on imported fuels to meet its primary energy needs. However, Bhutan has a significant hydroelectric power generation potential of about 30,000 MW, of which about 16,000 MW is considered to be economically feasible. Current hydropower installed capacity is only 444 MW, mainly from the Chukha hydropower plant (336 MW), although the 1,020 MW Tala hydropower plant currently is under construction.

Nearly **85%** of the population is scattered in rural areas; and only **20-30%** of the population of 657,000 has access to electricity. Hence, electricity consumption is relatively low and current maximum demand is about 100 MW. Given the current level of domestic consumption, Bhutan has enjoyed exporting surplus electricity to India, and electric power export has become a key source of revenue since completion of the Chukha hydropower plant. During the 8th Five-Year-Plan (FYP) for 1996 to 2001, power export is estimated to contribute **40%** of total national revenue, as compared with **25%** during the 7th FYP.

3.1 ENERGY POLICIES AND REGULATIONS

3.1.1 National Energy Policy

Since the power sector is the major source of revenue for the government, development of the energy sector in Bhutan is of crucial importance. Utilization of this hydropower potential, combined with generation and transmission of hydroelectric energy for export, are key components in each of Bhutan's five-year plans. Under the 8th FYP, the Government of Bhutan aims to accelerate economic growth and improve living standards, while at the same time ensuring the preservation of the country's environment and cultural heritage. The plan also focuses on revenue-generating hydropower development and industrialization.

Under the current structure of the power sector, policy, regulation, system development, and operation of the power sector (including generation and distribution) are the responsibility of the Department of Power. Separate autonomous bodies were created to undertake general administration and coordination of specific hydro power plants, for example, the Chukha Hydro Power Corporation and the Kurichu Project Authority.

An action plan proposed by the Asian Development Bank (ADB) for the privatization of the Department of Power by the year 2002 has commenced. All preparatory work, such as the formulation of Electricity Acts, has been completed. The Water Development Management Plan and an update of the Power System Master Plan will be prepared during the 9th FYP.

3.1.2 Energy Conservation and Power Sector Demand-Side Policy

Bhutan has included energy conservation and efficiency projects in the 9th FYP for 2002 – 2007. In particular, awareness campaigns for standard setting and labeling programs and for pilot projects on lighting using Compact Fluorescent Lamps (CFL) are highlighted.

3.2 ELECTRICITY DEMAND AND SUPPLY

3.2.1 Electricity Demand

Annual domestic electricity consumption in Bhutan increased from 217 GWh at the end of 6th FYP to 341 GWh by mid-1995. The overall energy demand growth during 7th FYP averaged **19%** per annum due to establishment of industrial plants such as Bhutan Board Products Ltd., Bhutan Carbide and Chemicals Ltd., and Bhutan Ferro Alloys Ltd. These establishments account for nearly **80%** of the industrial energy consumption. Energy demand growth in the commercial and residential sectors has been slower at about **5%** per annum, mainly due to the limitations of urban and rural electrification systems.

Table 3-1: Electricity Consumption (GWh)

Year	1996	1997	1998	1999
Electricity Consumption (GWh)	na	366.4	375.2	390.8
Growth from the previous year	na	na	2.4%	4.2%

Source: CSO, Planning Commission

The system load profile in Bhutan typically shows two peaks – morning and evening, with the latter being predominant and reflecting an increased demand from household appliances. There is significant variation in demand in summer and winter periods, with heating being the major contributor to the peak load in the winter months. In Thimphu, there is an additional demand of 4 to 8 MW in winter compared to the summer. The average daily load profiles in winter and summer in Thimphu are shown in Figure 3-1.

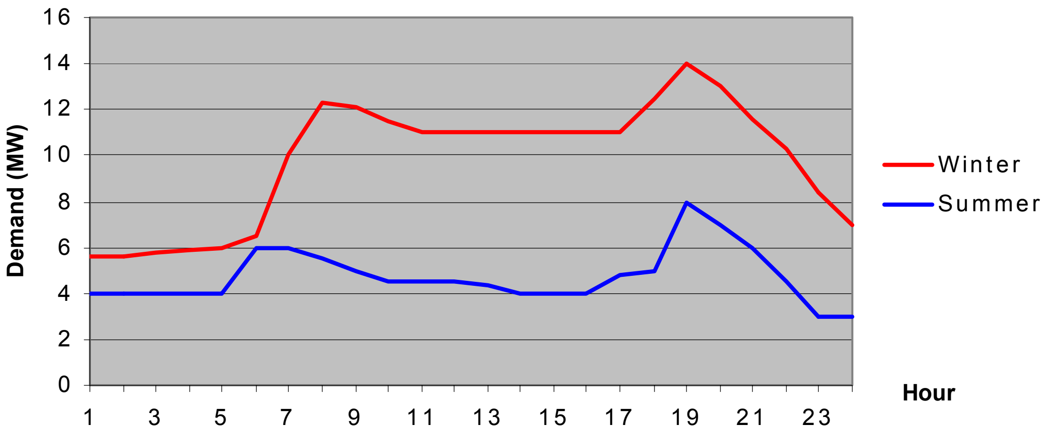


Figure 3-1: Daily Load Profile, Thimphu – Recorded during January & June 2000

3.2.2 Electricity Supply

Hydropower accounts for **96%** of the current installed capacity and offers the major potential for future capacity additions. Considering its vast resources and possibility of run-of-river schemes, hydropower has added benefits including minimum environmental and ecological impacts. Details of total installed capacity are given in Figure 3-2 and generation in Table 3-2.

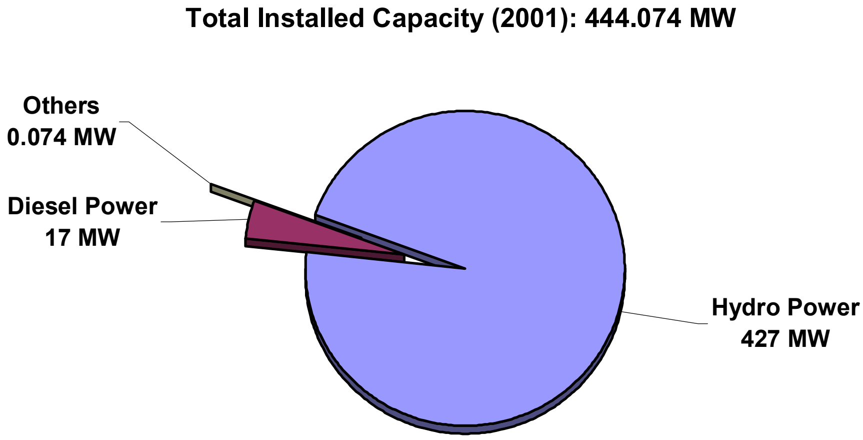


Figure 3-2: Electricity Generation Mix in Bhutan, 2001

Table 3-2: National Power Generation During 1990-1995 (GWh)

Source	1990-91	1991-1992	1992-1993	1993-1994	1994-1995
Mini Hydro	6.619	7.364	5.046	5.488	5.880
Micro Hydro	0.876	0.876	1.445	2.015	2.015
Chukha Hydro	1542.41	1544.37	1677.81	1679.24	1623.31
Diesel power	0.046	1.315	3.059	1.085	1.069
Total Generation	1549.95	1563.93	1687.36	1687.83	1632.88

Source: 8th FYP Report (1997-2002)

3.2.3 Power Development Plan

Currently, only about **1.42%** of the hydropower potential in Bhutan is being utilized. The development of hydro resources to meet future demand is a priority and many projects are planned or under construction.

Two major project developments, the 60 MW Kurichu and 1,020 MW Tala hydropower projects were included in the 8th five-year plan. The Kurichu project was scheduled to be completed at the end of 2001 and the Tala project by 2004-2005. A feasibility study for the 360 MW Mangdechu hydropower project was recently completed and a study for the 870 MW Punatsangchu project is currently in progress. While these large projects are designed primarily for export, other small hydropower projects – Sengor (50 kW), Sakten (200 kW) and Tang (400 kW) have been planned for the 9th FYP.

With **85%** of the population living in scattered rural areas, rural electrification is also a key priority. Bhutan also has a scheme focusing on electricity system improvements – efficiency, voltage regulation, network upgrading, planned maintenance and replacement of old equipment. Inadequate investment capital, limited skilled manpower and lack of advanced technologies also are major barriers to development of the power sector.

3.3 ELECTRICAL APPLIANCES AND EQUIPMENT

With only 35,000 electricity consumers and total estimated rural households of around 100,000, the percentage of domestic households in Bhutan using electrical appliances is naturally very low. According to the CIA World Fact book, there are approximately 11,000 televisions in Bhutan. Formal statistical data for other household appliances is not available. Market surveys and interviews conducted by CERF/IIEC revealed that Bhutan imports about 300,000 lamps per annum, of which **60%** are incandescent lamps and the rest are fluorescent lamps. Import figures for 1999 show the following – refrigerators (~4,000 units), electric room heaters (~10,000 units) and water heaters (~5,000 units). Since system daily load profiles are not available, CERF/IIEC has estimated from information made available from Bhutan that about 10 MW is added to the evening system peak demand from domestic appliances.

The construction of several energy intensive industries since 1993, such as Bhutan Board Products Ltd., Bhutan Carbide and Chemicals Ltd., Bhutan Ferro Alloys Ltd. and Penden Cement Authority Ltd., has made a significant impact to the share of electricity consumption in the industrial sector. Electric motors have the largest end-use electricity consumption in the industrial sector.

4.1 SELECTED APPLIANCES

Among primary household appliances, all electricity consumers use either incandescent or fluorescent lighting. Based on limited sales data available, it appears that incandescent lamps[4] dominate the market. Based on experiences in other countries, it is considered that S&L for fluorescent lighting would yield the greatest energy efficiency benefits to Bhutan. In addition to lighting, the impact of two other appliances—rice cookers and refrigerators—was considered. In the absence of statistical appliance data from Bhutan, appliance efficiency gains from programs in other countries were used in the analysis.

4.2 ELECTRICITY DEMAND AND ENERGY IMPACT

The estimated electricity demand and energy impacts from S&L programs for lighting, rice cookers and refrigerators were analyzed for two scenarios, as described below. The variables considered in the two scenarios are only for lighting, while the impacts of S&L on rice cookers and refrigerators remain constant. The assumptions made for the impact analysis are given in Appendix B.

4.2.1 Scenario I

Bhutan introduces an energy efficiency standard that prescribes minimum quality, efficiency and lifetime for Compact Fluorescent Lamps (CFLs)[5] that are both imported and locally manufactured. In addition, an energy labeling program is introduced for CFLs, supported by a public awareness campaign to promote efficient lighting. As a result of the S&L programs, the CFLs will penetrate the incandescent lamp market share at the rate of **10%** per annum.

4.2.2 Scenario II

Bhutan introduces a more aggressive S&L program for CFLs and as a result, CFLs penetrate the incandescent lamp market at the rate of **15%** per annum. In addition to the CFL program, Bhutan also introduces an S&L program for fluorescent tubes[6] and as a result, the

[4] An incandescent lamp works by heating a filament, a double-spiral coil of very thin tungsten wire, with an electric current until it radiates visible light. Modern tungsten filaments operate at about 2,500° C and, at that high temperature the lamp life is around 1,000 hours. Because only around 12% of the thermal radiation is visible, an incandescent lamp can deliver only 11-14 lumens per watt.

[5] Compact fluorescent lamps (CFLs) are miniaturized versions of fluorescent tube lighting. Some units consist of a lamp and a separate ballast, while others have the ballast built in. CFLs are designed with the bases that can directly fit into the conventional sockets for incandescent lamps. CFLs produce more light for less power and typically last for 6,000 to 8,000 hours. A good CFL will deliver 55-60 lumens per watt, compared to 11-14 lumens per watt for an incandescent lamp, thus an equivalent energy saving of around 80%.

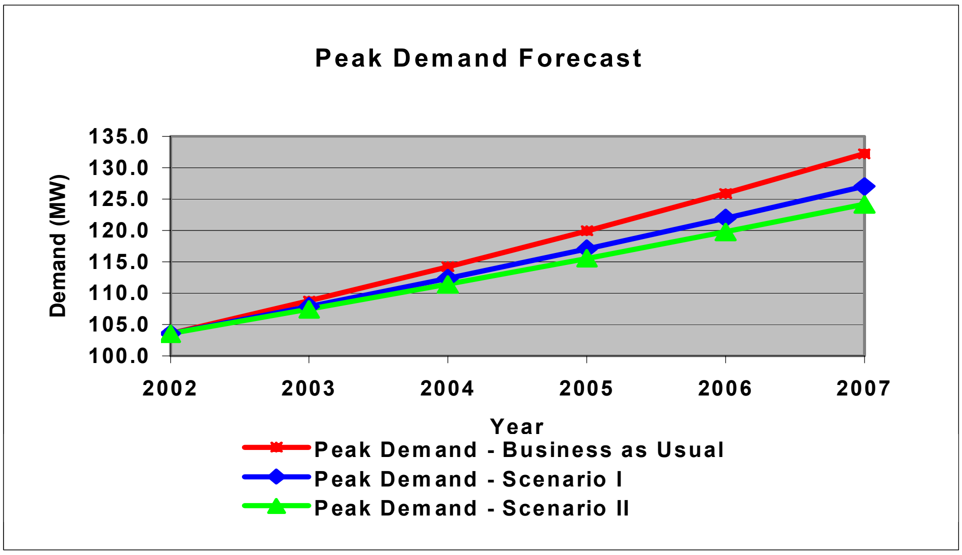
[6] A fluorescent tube or a fluorescent lamp is an electric discharge lamp that generates light from a phosphor-coated tube. To operate a fluorescent lamp, a device called “ballast” must be equipped in the lighting circuit. The fluorescent lamps come in a wide range of lengths and a number of different diameters. The older fat “T12”, or 1.5 inch (38 mm) diameter tube is less efficient than the thinner “T8”, or 1.0 inch (26 mm) diameter tube. T8 tubes paired with electronic ballasts can reach efficiencies approaching 100 lumens per watt, while the older technologies may yield about 65 lumens per watt.

market for 40W fluorescent tubes (T12) is totally transformed to using 36W fluorescent tubes (T8) within 5 years.

4.2.3 Estimated Benefits

With the introduction of an energy S&L program covering fluorescent lighting, rice cookers and refrigerators, complemented by a public awareness campaign to promote efficient appliances, Bhutan could potentially save between 5 MW to 8 MW[7] in peak demand over a five-year period. Considering current transmission and distribution losses, this corresponds to a generation capacity saving between 6 MW to 9 MW or more than Nu. 180 million[8] capital investment in new capacity. The corresponding reduction in energy consumption is estimated at 12 GWh or Nu. 8 million[9] over the five-year period. In return, this saving could generate Nu. 12 million from exports to neighboring India.

Impacts of the S&L programs as per scenarios I and II are illustrated in Figure 4-1 and Figure 4-2, and details of the analysis are given in Appendix B.



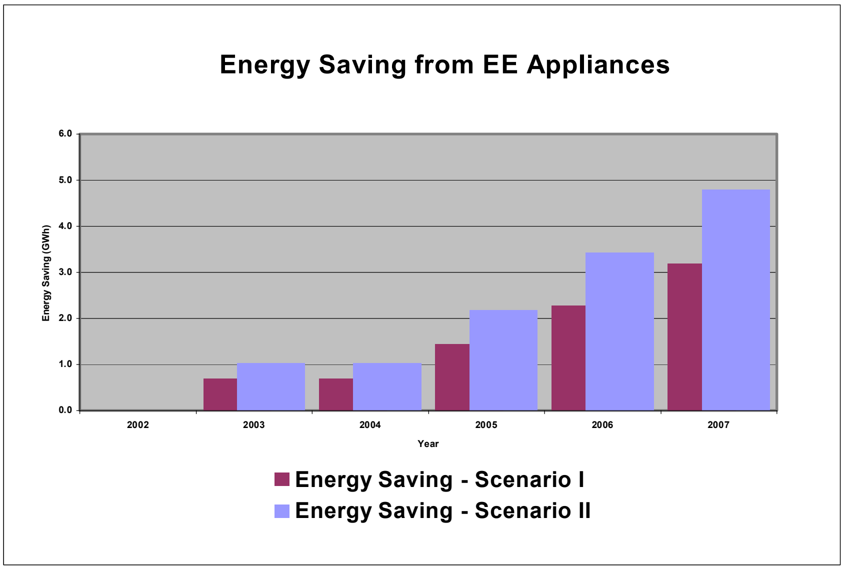
Source: IIEC

Figure 4-1: Impacts of S&L programs on Electricity Peak Demand

[7] The potential 5 to 8 MW peak demand saving is conservatively estimated from daily usage patterns of energy efficient rice cookers (2 hrs/day) and refrigerators (5 hrs/day cycling), and the use of energy efficient lamps during the evening peak hours (4hrs/day). See details of the analysis in Appendix B

[8] Considering 10% transmission and distribution losses, 5 to 8 MW peak demand is equivalent to 6 to 9 MW generating capacity (5 to 8 MW x 110%). Based on existing hydropower plant construction, it is estimated that each MW of hydropower plant costs Nu. 30 million, so Bhutan requires Nu. 180 million to build 6 MW power plant. See details of the calculations in Appendix B.

[9] Based on electricity tariff Nu. 0.7 per kWh. See details of the calculations in Appendix B.



Source: IIEC

Figure 4-2: Impacts of S&L Programs on Energy Saving

Section 5 Recommendations

The analysis in Section 4 reveals the potential benefits of an EE S&L program for lighting, rice cookers and refrigerators in Bhutan. In addition, EE S&L programs in other countries for other domestic appliances such as electric fans, ballasts, room heaters and water heaters, have been shown to yield significant benefits. However, due to limited information available on other appliances, the analysis of potential benefits of appliance S&L in Bhutan could not be undertaken at this time.

To broaden the perspective of benefits of appliance S&L programs, it would be necessary for Royal Government of Bhutan to gather more information on appliance saturation and end-use consumption in different segments of the residential sector. Market Research to determine customer awareness, appliance types and purchasing preferences also would be required.

In order to establish a sustainable EE S&L program in Bhutan, the following steps are recommended:

1. Establish a Steering Committee with the responsibility for setting energy efficiency standards and labeling for appliances. Such a committee should ideally be comprised of representatives from the following major stakeholders:

    - Planning Commission, Royal Government of Bhutan
    - Department of Trade, Ministry of Trade and Industry
    - Department of Power, Ministry of Trade and Industry
    - Department of Revenue and Customs, Ministry of Finance

2. Prepare a Plan of Action for S&L over a specified period.
3. Conduct a detailed feasibility study to include: market surveys on customer awareness and preferences; appliance saturation and usage profiles; scope of appliance efficiency gains; detailed cost and benefit analysis; institutional framework for S&L; and power system characteristics that are likely to impact on S&L.
4. Establish a mechanism to harmonize standard setting and labeling programs with ongoing programs in neighboring countries.

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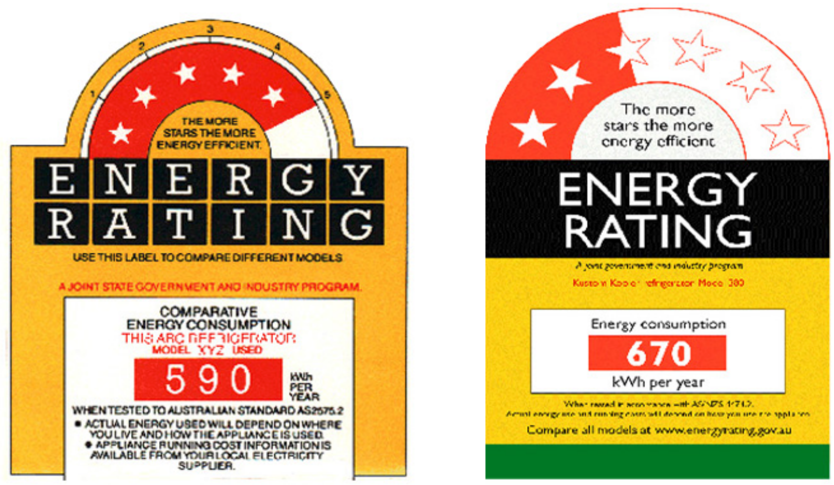
AUSTRALIA

Energy Standards and Labeling Program

The energy labeling and standards program in Australia originated in 1982, when the Government of the State of New South Wales (NSW) first realized energy savings from energy efficient appliances such as refrigerators and freezers. In 1985, after unsuccessful attempts to introduce a nationwide voluntary scheme, the NSW and Victoria Governments enacted regulations mandating energy labeling for refrigerators, freezers, dishwashers and air conditioners. Australia's two largest cities, Sydney and Melbourne, account for some **60%** of the national appliance market. The mandatory energy labeling for refrigerators and freezers became effective in 1986. Labels were later introduced for room air-conditioners and dishwashers in 1987 and 1988, respectively. Now the remaining States have adopted these energy labels. To complement the energy-labeling program, Minimum Energy Performance Standards (MEPS) for refrigerators, freezers and electric storage water heaters were introduced in 1999. MEPS for three-phase packaged air conditioners and three-phase electric motors were implemented in 2001/02. Fluorescent lamp ballast MEPS are under consideration for 2003.

The energy-labeling program in Australia has been successful because suppliers perceived a commercial value in having 5 star products (more stars denote more efficiency). Once products have reached 5 stars, the incentive for suppliers to introduce better efficient models was reduced. Following several years of negotiation between government and industry, the Energy Rating Label was revised in 2000, increasing the efficiency levels needed to obtain equivalent star rating. For example, 4 stars under the old system may now only rate 2 or 3 stars under the new (Figure A-1).



Original Australian Label (1986) Revised Australian Label (2000)

Figure A-1: Australian Original and Revised Labels

Implementation Structures and Costs

In Australia, labeling and MEPS programs are controlled by the state rather than the national legislature. The labeling program requires the cooperation of several organizations. Firstly, each State and Territory Government is responsible for legislation, regulations and administration. This includes requiring labels to be displayed, monitoring performance and imposing penalties for non-compliance. Secondly, in order to gain consistency across the country, the National Appliance and Equipment Energy Efficiency Committee (NAEEEC) has been established to provide a coordinating role for the program. NAEEEC determines policy and sets the future directions for labeling. Finally, Standards Australia is charged with establishing test procedures and with publishing special regulatory standards that show how to calculate ratings and configure the labels and specify other program requirements.

It is mandatory for manufacturers and importers to register energy labels for designated appliances before retailers in Australia can sell them. The cost of energy performance testing as well as producing and fixing labels are passed on to consumers. All administration costs for the program that burden the government or electric utilities are also passed on to consumers. These costs include costs to cover policy and regulation, check testing of appliances and promotion. The costs of promotion include the cost of retail liaison staff, as well as production and distribution of guides and leaflets.

Results

The Australian energy-labeling program has been very successful. Among randomly selected appliance buyers who participated in a 1993 survey, nearly **90%** were aware of the energy label and **45%** used the information on the label to compare models on the market. In another survey (1991), it was found that **28.4%** of respondents considered the energy-efficiency rating to be the most important factor when purchasing a new electrical appliance. The energy-labeling program has been attributed to reducing energy consumption of the labeled appliances by an estimated **11%**, or 94 GWh, in 1992. Refrigerators and air conditioners consumed **12%** and **6%** less electricity, respectively. This amounted to a **1.6%** decrease in the total household electricity consumption in Australia. With an introduction of MEPS, a further reduction of between **14%-33%** in refrigerator energy consumption has been achieved.

EUROPE

Energy Standards and Labeling Program

After 16 years of debate, the European Commission (EC) enacted a Framework Directive for mandatory energy labeling in 1992. This grants the EC the authority to issue energy labels for appliances (refrigerators,freezers,air-conditioners,washing machines,clothes dryers, dishwashers, ovens, water heaters, and lighting sources) without seeking additional political approval from the Council of Ministers or the European Parliament. It is the responsibility of each individual Member State to translate directives into laws, only then do the labeling requirements become mandatory. In terms of legal implementation, all 15 EU Member States have now implemented the directives, but most were late in doing so. Only four countries met the implementation deadline of January 1995, an additional seven countries completed the procedure within one year after the deadline, the remaining four were staggered over the next three years. The EU appliance energy labels all follow a similar format. The energy efficiency of a given appliance is ranked into one of 7 bins graded from A to G, A being the *most efficient* and G being the *least efficient*.

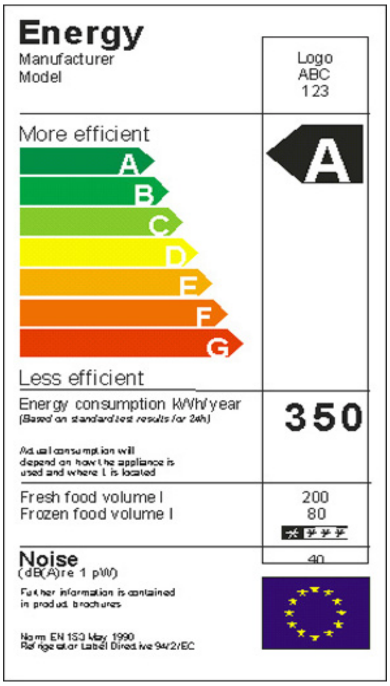


Figure A-2: European Label

There have also been attempts to improve appliance efficiencies in a non-regulatory manner but those efforts are not uniform. Another EC directive in 1992 allowed for the introduction of an EU-wide eco-labeling scheme. This voluntary program covers several appliances, which must also meet energy efficiency criteria. The eco-label can be incorporated into the design of the comparative label.

Unlike energy labeling, there is no framework legislation giving the Commission authority to introduce or revise energy efficiency standards on an on-going basis. European Union members need to gain approval from the EC and the Parliament in order to introduce or revise mandatory energy efficiency standards for any product. To date only two appliances have mandatory standards. MEPS for domestic gas or oil fired hot water services were approved in 1992, taking effect in 1998, and the refrigerator and freezer MEPS, which was approved in 1996, and took effect in 1999. The parliament has also recently approved a proposal covering MEPS for Fluorescent Lighting Ballasts.

Implementation Structures and Costs

Member States are responsible for all aspects of implementation including compliance, label accuracy, and educational and promotional activities. Product suppliers need to provide proof of appliance efficiency and are also responsible for the supply of labels and brochures in appropriate languages.

Results

The mandatory nature of the program has spurred manufacturers to improve the efficiency of their products. In Germany, for example, the efficiency of products in the market improved by **16.1%** from 1993 to 1996, while the efficiency of products in the market in Netherlands improved by **12.6%** from 1992 to 1995. In the United Kingdom, efficiency of refrigerator-freezers increased by **7.3%** between 1994 and 1996. The current trend in the EU suggests that the program is expected to save 278 TWh between 1996 and 2020 for refrigerators, freezers, and refrigerator/freezers alone; this is roughly a **10%** decrease in projected electricity demand for these appliances. The estimated savings translate into more than US$40 billion in avoided electricity spending for consumers, if constant real electricity prices are assumed.

PHILIPPINES

Energy Standards and Labeling Program

After years of co-ordination with manufacturer associations and the Department of Trade and Industry's Bureau of Product Standards (BPS), the Philippine Department Of Energy (PDOE) launched the Standards and labeling program in late 1993, and began labeling air conditioners in early 1994. Air conditioners, both imported and domestic models, are required to meet a minimum efficiency standard and are to be labeled. Air conditioners are given priority because, while only penetrating a small fraction of households, they represent one of the fastest growing electricity end-uses in the residential sector. In 1997, the standard was tightened so that the Energy Efficiency Ratio (EER) increases 5 percent every three years until 2002. In late 1999, the Fuels and Appliance Testing Laboratory (FATL) launched the energy-labeling program for refrigerators and freezers and the program became mandatory in 2000. The mandatory energy standards and labeling of electromagnetic fluorescent ballasts and split-type air-conditioners is to begin in 2002.

Figure A-3: AirCon and Ballast Label

The energy label for single-package room air-conditioners is provided in Figure A-3.

Implementation Structures and Costs

The PDOE, BPS and the Association of Home Appliance Manufacturers (AHAM) jointly administer the AirCon program, while BPS is responsible for enforcing the standards. PDOE also established the Fuels and Appliance Testing Laboratory (FATL), which serves as a neutral testing laboratory to verify manufacturers' assertions of the efficiency of their units. The annual operating cost of FATL is about US$160,000 to $200,000 and the initial construction of the laboratory cost US$675,000. The average price of an air conditioner increased by US$30, about **5%** of a unit's total cost, due to the program.

The PDOE also administers the public awareness campaign. One of PDOE's most recent initiatives is a nationwide campaign, known as POWER PATROL, an awareness-building campaign initiated by the private sector and supported by the government. The campaign gives emphasis and brings into focus the significance of power conservation and the efficient use of energy through the Committee on Power Conservation and Demand Management (CPCMD). To push the campaign to cover all sectors, the CPCDM formed three task forces which serve as its implementing arms: a task force for schools and educational institutions, a task force for commercial and industrial establishments and a task force for household and villages.

Results

Before the program started, only half of the annual sales volume for small-sized, window-type air conditioners met the standard, while none of the larger units did. By forcing these units off the market, the program had an immediate and pronounced effect in the overall efficiency of air conditioners in the market. Due to the “push” of standards and the “pull” of labels, an analysis conducted by FATL suggests an improvement of **23%** in energy consumption of all air-conditioning units between 1992 and 1996. Estimates of the program are preliminary at best, but it appears that the standards component of the program resulted in first-year capacity savings of 6 MW and energy savings of over 17 GWh. The estimates do not incorporate efficiency improvements in split systems or from the labeling component of the program. The impact of the program will increase with time because the number of air conditioners in the country is rising dramatically. In 2000, the average EER of Room Air Conditioner (RAC) products sold was 10.1 for below 12,000 kJ/h and 9.6 for above 12,000 kJ/h.

SOUTH KOREA

Energy Standards and Labeling Program

A surplus of electric power capacity during the summer in Korea abruptly fell from **52%** in 1987 to **5%** in 1991.[10] Major appliances, except air conditioners, are already saturated in the market. The saturation of room air conditioners has rapidly increased. The energy standards and labeling program was introduced in 1992, and it has played a key role in curbing the steep growth of electricity consumption. In the beginning, 6 items were included in the program, i.e. refrigerators and freezers, room air-conditioners, incandescent lamps, fluorescent lamps, ballast and passenger cars. The energy efficiency standards program consists of a mandatory energy efficiency rating label, a Minimum Energy Performance Standard (MEPS) and a Target Energy Performance Standard (TEPS). MEPS is mandatory; TEPS is voluntary.

Figure A-4: Korean Label

The rating label established a 5-rank system for labeling the energy use of appliances. The most energy efficient models (products that correspond to TEPS) receive a grade 1, and the least efficient models (products that correspond to MEPS) receive a grade 5.

Implementation Structure and Costs

The Ministry of Commerce, Industry and Energy (MOCIE) established the Korean Energy Management Corporation (KEMCO) to implement energy efficiency and conservation programs in 1980. MOCIE is responsible for establishing the framework for the program, including setting/revising and announcing standards. KEMCO is also charged with implementation and monitoring of the program. The Korea Institute of Energy Research (KIER**)** is mainly involved in standards

[10] CLASP February 2001- Energy Efficiency Labels & Standards- “ A Guidebook for Appliances Equipment and Lighting”.

setting (in consultation with MOCIE, KEMCO) and the manufacturers and importers, and formulates energy efficiency standards and rating labeling rules.

Eight laboratories and research institutes provide testing services in support of the standards and labeling programs. Upon testing the product, the testing laboratory provides the manufacturer or importer with an official efficiency level, which the manufacturer or importer then reports to KEMCO.

Results

A survey in 1994 and 1996 by KEMCO has shown that:

- The program has very high visibility and recognition.
- **85%** of consumers and **96%** of appliance purchasers were aware of the label.
- **72%** of consumers said they used the information to compare appliances prior to purchase.
- The result of the survey showed that consumers gave energy efficiency equal importance with other key appliance characteristics such as price, function, brand and size.

The percentage of energy efficient appliances in the market (grade 1 or grade 2) has steadily increased from **53.3%** in 1993 to **67.5%** in 2000, in spite of the reinforced and higher level energy efficiency standards and rating in 1996, 1999, 2001 for each product. Between 1993 and 2000, refrigerators and air-conditioners have shown an improvement in efficiency of **74%** and **54%** respectively.

THAILAND

Energy Standards and Labeling Program

Thailand has energy efficiency labeling programs for refrigerators, air conditioners and ballasts for fluorescent lamps under the national DSM plan. All programs are entirely voluntary and are not associated with minimum energy efficiency standards. The Electricity Generating Authority of Thailand (EGAT), the national generating utility, administers the programs through its DSM Office. EGAT established voluntary labeling programs for the two largest energy-consuming appliances in the residential sector – refrigerators and air-conditioners in 1995 and 1996 respectively (Figure A-5). The energy efficient ballast-labeling program was introduced in 1998. Currently, the Thai government is expanding the voluntary labeling programs by establishing minimum efficiency performance standards (MEPS) for air-conditioners, refrigerators, ballasts, compact fluorescent lamps (CFLs), fluorescent lamps (FLs) and motors.

The efficiency scale on the label for each model is 1 to 5, with 5 being the most efficient. Starting from January 2001, the efficiency level of each category on single-door refrigerator label was increased by **20%**.

Administrative Structure and Costs

Aside from EGAT, other government institutions involved in setting up standards and labeling programs include: the National Energy Policy Office (NEPO), the Thailand Industrial Standard Institute (TISI), the Department of Energy Development and Promotion (DEDP) and the Office of Consumer Protection (OCP). NEPO has a mandate to formulate national energy policy while DEDP is responsible for implementing the policy. Both NEPO and DEDP have legal authority to issue energy efficiency standards and labels. Testing for EGAT's voluntary labeling programs for refrigerators and air-conditioners is done at The Thai Industrial Standard Institute (TISI).

EGAT has allocated US$ 7.8 million for the refrigerator program and US$47 million for the air-conditioner program. EGAT launched a consumer awareness campaign promoting the importance of saving energy and became one of the largest advertisers in Thailand during 1995-1996. In addition to the EGAT nationwide television campaign, manufacturers also launched promotional campaigns emphasizing the energy-saving benefits of their products.

Original Thai Label (1995) Revised Thai Label (2001)

Figure A-5: Thai Original and Revised Labels

Results

The success of the programs was due both to market pull from consumer demand and market push from the voluntary agreements made by manufacturers. When the refrigerator labeling program began in 1995, only one model earned a "5" rating. Out of the participating refrigerators (i.e. refrigerators for which manufacturers requested labels), **33%** were rated at 3, **55%** were rated at 4, and **12%** were rated at 5. The share of "5" rating refrigerators increased from **12%** in 1995 to **96%** in 1998. The average energy consumption of participating refrigerators dropped by **12%** between **1995 and 1999. The Market share of "5" rating air-conditioners also increased from 19% in 1996 to 38**% in 1998.

As of June 2000, EGAT estimated that the refrigerator and air-conditioner labeling programs have reduced 168 MW in peak demand and 1,167 GWh in energy consumption. These figures have exceeded EGAT's initial expectations by more than three times.

ASSUMPTIONS USED IN THE ANALYSIS

Due to the lack of comprehensive appliance consumption data, the analysis of potential impacts from the energy efficiency standards and labeling programs in Bhutan includes only those domestic appliances shown in Table B-1.

Table B-1: Types of Appliances Included in the Analysis

Appliance	Estimated Units in Operation (Thousand)
Incandescent lamp (40W)	300
Fluorescent lamp (T12, 40W)	100
Rice Cooker (500W)	20
Refrigerators (250W)	5

Source: Industry interviews and estimation

The estimated reduction of peak demand from 2002 to 2007 resulting from S&L programs for lighting, rice cookers and refrigerators and corresponding energy savings is derived from the accumulation of decreased energy consumed due to energy efficient appliances over the 5-year period. The assumptions used in the analysis are given in Table B-2:

Table B-2: Assumptions for Impact Analysis

Particular	Assumption	Basis or Source
Average Energy Cost	Nu. 0.70/kWh	8th Five Year Plan Report
Hydro Power Plant Construction Avoided Cost	Nu. 30 million/MW	MW based on construction costs of Kurichu and Tala power plant
Daily load profile	Same pattern for over next 5 years	DOP's statistic
Electricity demand growth	8% per annum	
Appliance market growth	6% per annum	
Electrified household (2001)	35,000	DOP's statistic
Lamps used in each electrified household	Ratio Incandescent: fluorescent tube: CFL = 6:3:0.1	Import statistic 1999
Lamps wattage and daily burning hours	Incandescent lamps = 40W CFLs = 10W T12 Fluorescent tube = 40W T8 Fluorescent tube = 36W Daily burning hours = 4 hrs.	A fluorescent tube is equipped with a standard ballast (10W) in each lighting circuit.
Average Rice Cooker Wattage and daily usage hours	Standard Model = 500W Energy Efficient Model = 450W Daily usage hours = 2 hrs. (1 hr. in the morning and 1 hr. in the after noon)	Data published by Nepal Electricity Authority and the energy efficient model is 10% more efficient than the standard model.

Average Refrigerator Wattage and daily usage hours	Standard Model = 250W Energy Efficient Model = 220W Daily usage hours = 5 hrs.	Based on average daily kWh consumed of standard and energy efficient refrigerators in Thailand
Coincidence Factor	Lamps = 0.8 Televisions and rice cookers = 0.5 Refrigerators = 0.25	
Penetration rate of 10W (average) CFLs to 40W (average) incandescent lamp market	Scenario I: 10% per annum Scenario II: 15% per annum	
Penetration rate of 36W fluorescent tubes to 40W fluorescent tube market	Scenario I: 0% per annum Scenario II: 20% per annum	
Penetration rate of 450W rice cookers to 500W rice cooker market	Scenario I: 10% per annum Scenario II: 10% per annum	
Penetration rate of 250W refrigerators to 220W refrigerator market	Scenario I: 10% per annum Scenario II: 10% per annum	

ENERGY SAVING AND BENEFITS CALCULATION

Given the limitation of end-use data for electrical energy and appliances, the energy saving calculation is based on the daily load profile and number of key appliances in operation during the system peak period rather than on the household saturation of each appliance, unit energy consumption of each appliance and number of households. The following equations are used in the calculation of electricity peak demand and energy demand for the appliances included in the analysis.

Electricity Peak Demand (MW) = Σ [Number of each type of appliances in operation during the evening peak (in million) x Average nominal wattage (W) x Coincidence Factor] + Average daytime demand (MW) (1)

Energy Demand During the Evening Peak hours (GWh) = [2 x Σ Electricity Peak Demand generated by each type of appliances (MW)]/1000 (2)

Daily Energy Demand (GWh) = [Daily operating hours x Number of operating appliances (in million) x Average nominal wattage (W)]/1000 (3)

Equation (2), derived from the linear regression method, is limited only to the calculation of GWh generated by lamps during the evening peak hours, while equation (3) is used for the calculation of daily GWh from rice cookers and refrigerators.

Potential Peak Demand and Energy Saving

The potential 5 to 8 MW peak demand saving and 8 to 12 GWh cumulative energy saving over the 5-year period shown in Table B-4 are conservatively estimated from the assumptions on daily usage pattern of energy efficient rice cookers and refrigerators, and the use of energy efficient lamps during the evening peak hours as per current system load profile. The number of energy efficient appliances increases as per assumptions in scenario I and II. The analysis of benefits from energy S&L programs in this concept paper do not include the electricity saving from the use of efficient lamps during off-peak hours and other indirect social, environmental and economic benefits.

Financial Benefits

Peak Demand Saving	= 5 to 8 MW	
Transmission and Distribution Losses	= 10%	
Generation Capacity Saving	= 5 to 8 MW x 110% = 6 to 9 MW	(4)
Hydro Power Plant Avoided Costs	= Nu. 30 million/MW	(5)
Total Hydro Power Plant Avoided Costs	= (4) x (5) = **Nu. 180 to 270 million**	(6)
5-Year Cumulative Energy Saving	= 8 to 12 GWh	(7)
DOP's Local Electricity Tariff	= Nu. 0.70/kWh	(8)
DOP's Export Tariff	= Nu. 1.00/kWh	(9)
5-Year Consumer Saving	= (7) x (8) = **Nu. 6 to 8 million**	(10)
5-Year Government Revenue	= (7) x (9) = **Nu. 8 to 12 million**	(11)
Total Benefits	= (6)+(10)+(11) = **Nu. 194 to 290 million**	

Table B-3: Calculation of Peak Demand and Energy Saving

Peak Demand: Base Case	2001			2002			2003			2004			2005			2006			2007		
Domestic Appliance	Estimation (million units)	Evening Peak Demand (MW)	Daily Energy Consumed (GWh)	Estimation (million units)	Evening Peak Demand (MW)	Daily Energy Consumed (GWh)	Estimation (million units)	Evening Peak Demand (MW)	Daily Energy Consumed (GWh)	Estimation (million units)	Evening Peak Demand (MW)	Daily Energy Consumed (GWh)	Estimation (million units)	Evening Peak Demand (MW)	Daily Energy Consumed (GWh)	Estimation (million units)	Evening Peak Demand (MW)	Daily Energy Consumed (GWh)	Estimation (million units)	Evening Peak Demand (MW)	Daily Energy Consumed (GWh)
GLSs (40W)	0.300	9.600	0.019	0.315	10.080	0.020	0.331	10.584	0.021	0.347	11.113	0.022	0.365	11.669	0.023	0.383	12.252	0.025	0.402	12.865	0.026
Fluorescent tubes (40W)	0.105	4.200	0.008	0.110	4.410	0.009	0.116	4.631	0.009	0.122	4.862	0.010	0.128	5.105	0.010	0.134	5.360	0.011	0.141	5.628	0.011
CFLs (10W)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Television (100W)	0.011	0.550	0.001	0.012	0.578	0.001	0.012	0.606	0.001	0.013	0.637	0.001	0.013	0.669	0.001	0.014	0.702	0.001	0.015	0.737	0.001
Rice Cookers (500W)	0.020	5.000	0.020	0.021	5.250	0.021	0.022	5.513	0.022	0.023	5.788	0.023	0.024	6.078	0.024	0.026	6.381	0.026	0.027	6.700	0.027
Refrigerators (250W)	0.005	0.313	0.006	0.005	0.328	0.007	0.006	0.345	0.007	0.006	0.362	0.007	0.006	0.380	0.008	0.006	0.399	0.008	0.007	0.419	0.008
Additional evening peak		20	**0.05**		21	**0.06**		22	**0.06**		23	**0.06**		24	**0.07**		25	**0.07**		26	**0.07**
Average day time demand		79			83			87			91			96			101			106	
Total peak demand		**99**			**104**			**109**			**114**			**120**			**126**			**132**	

CFL for GLS market penetration rate	10%
T10 for T12 market penetration rate	0%
EE Rice Cookers penetration rate	10%
EE Refrigerator penetration rate	10%

Peak Demand: Scenario I	2001			2002			2003			2004			2005			2006			2007		
Domestic Appliance	Estimation (million units)	Evening Peak Demand (MW)	Daily Energy Consumed (GWh)	Estimation (million units)	Evening Peak Demand (MW)	Daily Energy Consumed (GWh)	Estimation (million units)	Evening Peak Demand (MW)	Daily Energy Consumed (GWh)	Estimation (million units)	Evening Peak Demand (MW)	Daily Energy Consumed (GWh)	Estimation (million units)	Evening Peak Demand (MW)	Daily Energy Consumed (GWh)	Estimation (million units)	Evening Peak Demand (MW)	Daily Energy Consumed (GWh)	Estimation (million units)	Evening Peak Demand (MW)	Daily Energy Consumed (GWh)
GLSs (40W)	0.300	9.600	0.019	0.315	10.080	0.020	0.298	9.526	0.019	0.278	8.891	0.018	0.255	8.168	0.016	0.230	7.351	0.015	0.201	6.432	0.013
Fluorescent tubes (40W)	0.105	4.200	0.008	0.110	4.410	0.009	0.116	4.631	0.009	0.122	4.862	0.010	0.128	5.105	0.010	0.134	5.360	0.011	0.141	5.628	0.011
Thin Tubes (36W)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CFLs (10W)	-	-	-	-	-	-	0.033	0.265	0.001	0.069	0.556	0.001	0.109	0.875	0.002	0.153	1.225	0.002	0.201	1.608	0.003
Television (100W)	0.011	0.550	0.001	0.012	0.578	0.001	0.012	0.606	0.001	0.013	0.637	0.001	0.013	0.669	0.001	0.014	0.702	0.001	0.015	0.737	0.001
Rice Cookers (500W)	0.020	5.000	0.020	0.021	5.250	0.021	0.020	4.961	0.020	0.019	4.631	0.019	0.017	4.254	0.017	0.015	3.829	0.015	0.013	3.350	0.013
Energy Efficient Rice Cookers (450W)	-	-	-	-	-	-	0.002	0.496	0.002	0.005	1.042	0.004	0.007	1.641	0.007	0.010	2.297	0.009	0.013	3.015	0.012
Refrigerators (250W)	0.005	0.313	0.006	0.005	0.328	0.007	0.005	0.310	0.006	0.005	0.289	0.006	0.004	0.266	0.005	0.004	0.239	0.005	0.003	0.209	0.004
Energy Efficient Refrigerators (220W)	-	-	-	-	-	-	0.001	0.030	0.001	0.001	0.064	0.001	0.002	0.100	0.002	0.003	0.140	0.003	0.003	0.184	0.004
Additional evening peak		20	**0.05**		21	**0.06**		21	**0.06**		21	**0.06**		21	**0.06**		21	**0.06**		21	**0.06**
Average day time demand		79			83			87			91			96			101			106	
Total peak demand		**99**			**104**			**108**			**112**			**117**			**122**			**127**	

CFL for GLS market penetration rate	15%
T10 for T12 market penetration rate	20%
EE Rice Cookers penetration rate	10%
EE Refrigerator penetration rate	10%

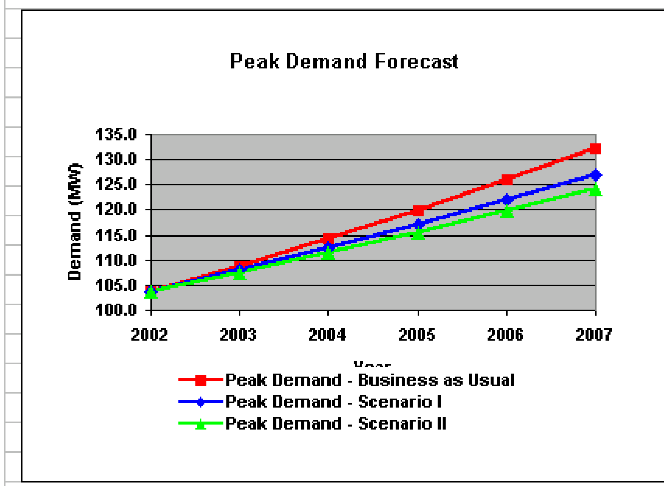
Peak Demand: Scenario II	2001			2002			2003			2004			2005			2006			2007		
Domestic Appliance	Estimation (million units)	Evening Peak Demand (MW)	Daily Energy Consumed (GWh)	Estimation (million units)	Evening Peak Demand (MW)	Daily Energy Consumed (GWh)	Estimation (million units)	Evening Peak Demand (MW)	Daily Energy Consumed (GWh)	Estimation (million units)	Evening Peak Demand (MW)	Daily Energy Consumed (GWh)	Estimation (million units)	Evening Peak Demand (MW)	Daily Energy Consumed (GWh)	Estimation (million units)	Evening Peak Demand (MW)	Daily Energy Consumed (GWh)	Estimation (million units)	Evening Peak Demand (MW)	Daily Energy Consumed (GWh)
GLSs (40W)	0.300	9.600	0.019	0.315	10.080	0.020	0.281	8.996	0.018	0.243	7.779	0.016	0.201	6.418	0.013	0.153	4.901	0.010	0.101	3.216	0.006
Fluorescent tubes (40W)	0.105	4.200	0.008	0.110	4.410	0.009	0.093	3.704	0.007	0.073	2.917	0.006	0.051	2.042	0.004	0.027	1.072	0.002	-	-	-
Thin Tubes (36W)	-	-	-	-	-	-	0.023	0.852	0.002	0.049	1.789	0.004	0.077	2.818	0.006	0.107	3.945	0.008	0.141	5.178	0.010
CFLs (10W)	-	-	-	-	-	-	0.050	0.397	0.001	0.104	0.833	0.002	0.164	1.313	0.003	0.230	1.838	0.004	0.302	2.412	0.005
Television (100W)	0.011	0.550	0.001	0.012	0.578	0.001	0.012	0.606	0.001	0.013	0.637	0.001	0.013	0.669	0.001	0.014	0.702	0.001	0.015	0.737	0.001
Rice Cookers (500W)	0.020	5.000	0.020	0.021	5.250	0.021	0.020	4.945	0.020	0.018	4.596	0.018	0.017	4.200	0.017	0.015	3.752	0.015	0.013	3.250	0.013
Energy Efficient Rice Cookers (450W)	-	-	-	-	-	-	0.002	0.511	0.002	0.005	1.073	0.004	0.008	1.690	0.007	0.011	2.366	0.009	0.014	3.106	0.012
Refrigerators (250W)	0.005	0.313	0.006	0.005	0.328	0.007	0.005	0.310	0.006	0.005	0.289	0.006	0.004	0.266	0.005	0.004	0.239	0.005	0.003	0.209	0.004
Energy Efficient Refrigerators (220W)	-	-	-	-	-	-	0.001	0.030	0.001	0.001	0.064	0.001	0.002	0.100	0.002	0.003	0.140	0.003	0.003	0.184	0.004
Additional evening peak		20	**0.05**		21	**0.06**		20	**0.06**		20	**0.06**		20	**0.06**		19	**0.06**		18	**0.06**
Average day time demand		79			83			87			91			96			101			106	
Total peak demand		**99**			**104**			**107**			**111**			**116**			**120**			**124**	

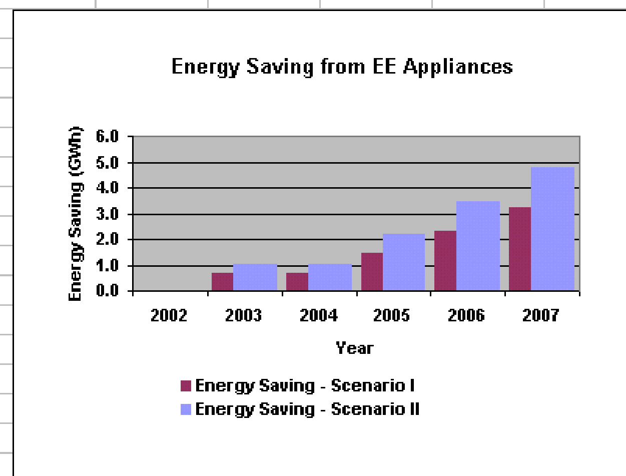
(Orange) Daily Energy Consumed from Domestic Appliances during Evening Peak Hours - Lighting & Televisions (equation 2)

(Yellow) Daily Energy Consumed from Domestic Appliances (both peak and off-peak hours) - Rice Cookers & Refrigerators (equation 3)

Table B-4: Summary of Peak Demand and Energy Saving

	2002	2003	2004	2005	2006	2007
Peak Demand - Business as Usual (MW)	103.6	108.8	114.2	119.9	125.9	132.2
Peak Demand - Scenario I (MW)	103.6	107.9	112.4	117.1	121.9	127.0
Peak Demand - Scenario II (MW)	103.6	107.4	111.4	115.5	119.8	124.1
Peak Demand saving, base case vs. scenario I, (MW)	**0.0**	**0.9**	**1.8**	**2.8**	**4.0**	**5.2**
Peak Demand saving, base case vs. scenario II, (MW)	**0.0**	**1.3**	**2.8**	**4.4**	**6.1**	**8.1**
Energy Demand from Appliances - Business as Usual (GWh)	21.1	22.1	22.1	23.2	24.4	25.6
Energy Demand from Appliances - Scenario I (GWh)	21.1	21.4	21.4	21.8	22.1	22.4
Energy Demand from Appliances - Scenario II (GWh)	21.1	21.1	21.1	21.0	21.0	20.8
Energy saving from EE Appliances - Scenario I, (GWh)	**0.0**	**0.7**	**0.7**	**1.4**	**2.3**	**3.2**
Energy saving from EE Appliances - Scenario II, (GWh)	**0.0**	**1.0**	**1.0**	**2.2**	**3.4**	**4.8**





Peak Demand Saving within 5 years - Scenario I (MW)	**5**
Peak Demand Saving within 5 years - Scenario II (MW)	**8**
5-Year Cumulative Energy Saving - Scenario I (GWh)	**8**
5-Year Cumulative Energy Saving - Scenario II (GWh)	**12**