ECO

PN-ACQ-191

Energy Conservation and Commercialization Project

A Program of USAID, Ministry of Power & ICICI

Market Potential for Branded Energy Efficient Products

JANUARY 2001

Activity 5
Milestone 5A

Principal Investigators:

Kapil Thukral, Nexant, Delhi
Brian Wood, Nexant, San Francisco
Anil Sachdeva, Consulting Engineers Company, Delhi

USAID Contract Number: LAG-I-809-98-00006-00

23865-809.0016

TABLE OF CONTENTS

S. No.	Title	Page #
	Preface	3
	Background	4
	Executive Summary	6
1	**The Backdrop**	9
1.1	Overview of Activities and Milestones	9
1.2	EE technologies under consideration	9
2	**The Approach**	12
2.1	Economic potential assessment	12
2.2	Market potential assessment	17
2.3	Discount rates	18
3	**Compact fluorescent lamps**	19
3.1	Segment share of existing light points	19
3.2	Technical potential	20
3.3	Economic potential	22
3.4	Market potential	23
4	**T8 lamps**	26
4.1	Segment share of existing light points	26
4.2	Technical potential	26
4.3	Economic potential	27
4.4	Market potential	28
5	**Electromagnetic ballast**	31
5.1	Segment share	31
5.2	Technical potential	31
5.3	Economic potential	32
5.4	Market potential	33
6	**Electronic ballast**	35
6.1	Segment share	35
6.2	Technical potential	35
6.3	Economic potential	36
6.4	Market potential	37
7	**T5 lamps with electronic Ballast**	39
7.1	Segment share	39
7.2	Technical potential	40
7.3	Economic potential	41
7.4	Market potential	41
8	**Energy efficient Refrigerators**	44
8.1	Segment share	44

8.2	Technical potential	45
8.3	Economic potential	45
8.4	Market potential	46
9	**Energy efficient Air-conditioners**	48
9.1	Segment share	48
9.2	Technical potential	48
9.3	Economic potential	49
8.4	Market potential	49
10	**Energy Efficiency Ceiling Fans**	51
10.1	Segment share	51
10.2	Technical potential	51
10.3	Economic potential	52
10.4	Market potential	53
11	**Energy efficient Motors**	55
11.1	Segment share	55
11.2	Technical potential	55
11.3	Economic potential	57
11.4	Market potential	58
	Annexure	61

Acronyms and Abbreviations

CCP	Combined cycle plant
COP	Coefficient of performance
CT	Current transformer
CFL	Compact fluorescent lamp
EE	Energy efficient
EM	Electro-magnetic
ESCO	Energy service company
GHG	Greenhouse gas
GLS	General lighting system
GOI	Government of India
GWh	Giga watt hour
HSD	High speed diesel
HT	High tension
IPP	Independent power producers
kW	Kilo watt
kWh	Kilo watt hour
LRMC	Long run marginal cost
LSFO	Low sulphur furnace oil
LT	Low tension
MW	Mega watt
SERC	State electricity regulatory commission

Preface

This report is a part of the deliverable for Milestone 5A, to analyze strategies for increasing the market opportunities for the branded manufacturing and develop recommendations for promotion of energy efficiency products in India.

The ECO project is being implemented by Bechtel National Inc (Nexant Inc) under a USAID contract, LAG-I-00-98-0000. This contract has been issued by the USAID Mission in New Delhi as a part of the IQC (Indefinite Quantity Contract) currents in place through USAID's Global Bureau. The project contract was signed in February 29, 2000 and continues through December 2003.

Background

The Government of India (GOI) and the US Agency for International Development (USAID) signed a joint project agreement on 28 January 2000 that calls for the implementation of the Energy Conservation and Commercialization (ECO) project. The ECO project will target the reduction of greenhouse gas emissions per unit of electricity generated and consumed in India.

India is currently the world's sixth largest and second fastest growing source of global greenhouse gases. This new initiative is in furtherance of the Joint Statement on Cooperation in Energy and Related Environmental Aspects signed in October 1999 between USA and India.

ECO aims to promote widespread commercialization of energy efficiency technologies and services in India, thereby contributing to the reduction in growth of GHG emissions. Assistance is provided for developing a market oriented policy environment for commercialization of energy conservation, and enhancing the capabilities of private and financial sectors for deploying market-based mechanisms for energy efficiency investments. The ECO project supports USAID's Climate Change Strategy, and will contribute to USAID / India's Strategic Objective for increased environmental protection in energy, industries and cities.

ECO will further facilitate the commercialization of energy services and technologies through a two-pronged strategy:

- Energy efficient market development and financing (Markets Component); and
- Energy efficiency policy and institutional reforms (Policy Component).

The Markets Component includes the following major Activities:

- Activity 1: Technical and project structuring services for sponsors
- Activity 2: Development of financial incentives for credit enhancement / risk mitigation
- Activity 3: Support to energy efficiency services industry
- Activity 4: Efficient technology promotion
- Activity 5: Market conditioning and promotion
- Activity 6: Non-sugar cogeneration market development

The Policy Component will cover policy, regulatory and institutional reform issues at the central and state levels, and will include the following major Activities:

- Activity 7: Energy efficiency policy and institutional support
- Activity 8: Energy efficiency standards for labeling for consumer appliances
- Activity 9: Energy efficiency improvements in Government facilities and private buildings
- Activity 10: Energy efficiency through regulatory reform and restructuring
- Activity 11: Electric utility DSM / energy efficiency capacity building
- Activity 12: Development of State energy efficiency financing schemes
- Activity 13: DSM / energy efficiency within privatized distribution utilities

Technical assistance (TA) and training will be provided to various Government agencies to help them create a market-oriented policy environment conducive to investment in efficiency. TA and training will be provided to the private and financial sector to design and implement energy conservation projects. The Ministry of Power (and the Bureau of Energy Efficiency, expected to be created after the proposed Energy Conservation Bill is enacted) will be the partner agency for the ECO project. State-level activities under the Policy Component will be coordinated with the State Regulatory Commissions and State Electricity Boards (or its functionally unbundled entities) of the focus state(s).

Executive Summary

Product categories

From the broad technologies whose data are available from previous USAID funded projects as well as other sources, certain narrow technologies / generic product categories are identified for assessment of technical potential (see report of ECO milestone 4B for details). For these very generic product categories, the economic and market potentials are assessed for specific customer segments (see Exhibit 0.1).

Exhibit 0.1: EE technology / Generic product categories and sector / segment combinations for assessment of economic and market potentials

S.No	*EE technology / generic product category*	*Sector / segment*
4	CFL lamp	Residential: high consuming urban, other urban, rural
		Commercial - all
		Industrial - small / cottage LT, other LT, HT
		Public lighting, other
5	T8 lamp	Residential: high consuming urban, other urban, rural
		Commercial - all
		Industrial - small / cottage LT, other LT, HT
		Public lighting, other
6	EE electromagnetic ballast	Residential: high consuming urban, other urban, rural
		Commercial all
		Industrial - small / cottage LT, other LT, HT
		Public lighting, other
7	Electronic ballast	Residential: high consuming urban, other urban, rural
		Commercial - all
		Industrial - small / cottage LT, other LT, HT
		Public lighting, other
8	T5 lamp & electronic ballast	Residential: high consuming urban, other urban, rural
		Commercial – all
		Industrial - small / cottage LT, other LT, HT
		Public lighting, other
9	EE refrigerators	Residential: high consuming urban, other urban, rural
		Commercial – all
10	EE room air-conditioners	Residential: high consuming urban
		Commercial – all
11	EE ceiling fans	Residential: high consuming urban, other urban, rural
		Commercial – all
		Industrial - small / cottage LT, other LT, HT
		Institutional
12	EE motors	Residential: high consuming urban, other urban, rural
		Commercial - all
		Industrial - small / cottage LT, other LT, HT
		Public lighting, other

Note 1: The residential consumer segments that are considered were selected on the basis of tariff categories that are relevant to the assessment of economic and market potential. The high consumption segment refers to domestic consumers using more than 300 kWh per month, for which a high tariff applies to marginal consumption at that level. See discussion on nominal tariffs below.

Note 2: Only EE motors manufactured in India considered

.0.2 The approach for economic and market potential assessment

Three indicators are used to assess economic potential for energy savings. In each, the life cycle cost of saved energy is compared to a certain measure of opportunity cost. The three measures of opportunity cost, as considered for analytical purposes are:

- long run marginal cost (LRMC)
- nominal electricity tariff rates
- actual payment of electricity bills

Likewise, three broad scenarios of market potential are presented:

- *With all market constraints, as at present*: In this scenario, the impact of various market barriers on translation of economic potential to market potential is assessed. The market barriers considered are consumer awareness (assuming suitable promotional programs are successfully implemented), compatibility of the technology with consumer needs and increasing consumer sophistication, product availability constraints due to problems in the supply chain, financial problems / constraints that impede investment in EE products / technologies and accord a low priority on such up-front expenditure etc.

- *With maximum relief of financial constraints*: In this scenario, it is assumed that to the extent any EE technology displays economic potential for energy savings from a national perspective, the GOI would offer all necessary fiscal and financial measures to promote it. It needs no reiteration that a successful implementation of such programs would be necessary.

- *With relief of supply chain constraints*: In this scenario, it is assumed that to the extent the penetration of any EE technology is impeded due to supply-chain barriers and problems, the necessary steps would be / can be / are taken to overcome them.

A comparison of the market potential assessed in the three scenarios gives the extent to which suitable intervention is possible.

0.3 Overview of major findings

The methodology for assessing the technical, economic and market potentials are detailed in subsequent sections, and the results are summarized in Exhibit 0.2. The following salient observations may be made and inferences drawn:

- Although the CFL perhaps has the largest technical potential for energy savings, its high upfront cost (that may be more than fifty times the cost of the incandescent bulb it replaces) is certainly an impediment to its ready market

acceptance – unless of course, suitably targeted and structured Government interventions are designed to overcome the financial constraints

- The T8 probably represents the other extreme – its low wattage savings per unit implies relatively technical potential for energy savings. However, the fact that the retail price of T8 is marginally below that of the FTL implies that a relatively large portion of the technical potential can be translated in to market potential

- In general, three groupings can be made:

  - EE products like CFL and EE refrigerator are such that their market penetration would increase substantially with a structured Government intervention program designed to overcome financial barriers
  - EE products like ballasts (both EE electromagnetic and electronic type), whose market potential would increase tremendously provided the inherent supply-chain constraints are overcome
  - Other EE products, for which both types of interventions (to overcome financial as well as supply chain constraints) are required

  It is important at this point in time, to consider the selection of two or more such product categories on the basis of the likelihood of the success of the various interventions.

Exhibit 0.2: Technical, economic and market potential estimates

	Technical potential	*Economic potential*		*Market potential*		
		National perspective	*Consumer perspective*	*Market constrained*	*Max relief of financial constraints*	*Relief of supply chain constraints*
GLS to CFL	13636	13636	257	72	5984	76
FTL to T8	1150	1150	793	494	680	571
Std to EE EM ballast	2130	2130	1128	90	162	901
Std EM to electronic ballast	3766	3766	1773	57	230	567
FTL to T5 w electronic ballast	7208	7208	701	227	4258	252
Standard to EE refrigerator	9077	9077	6851	140	3732	234
Standard to EE Air-conditioner	1687	1687	1378	832	1350	832
Std to EE ceiling fans	4,089	4089	458	73	835	243
Standard to EE motor						
- normal replacement	7382	7382	2264	133	506	881
- replacement instead of rewind	13241	5519	731	106	2610	133

1 The backdrop

1.1. Overview of Activities and Milestones

The specific objective of Activity 5 (Market conditioning and promotion) is to identify policy and innovative market mechanisms to promote energy efficient (EE) and environmentally friendly products in India. Activity 5 has a supply side orientation, to push and create markets through a collaborative effort between manufacturers, venders, financiers and other stakeholders (like ESCO's).

Activity 4 (Efficient technology promotion) has a demand side orientation. Its specific objective is to contribute to market transformation by addressing and overcoming barriers that are hindering the penetration and adoption of targeted EE technologies.

In both these activities, the focus is on electricity using EE technologies as in a product (eg. compact fluorescent lamp or motor) or a system (eg. pumping or air-conditioning), rather than process technologies (eg. dry cement kilns).

It should not be surprising therefore for work done under Activity 5 to draw on the work done for Activity 4 – and vice-versa.

This is indeed the case for Milestone 5A (to assess the economic and market potential for at least two branded EE products across residential, commercial and industrial sectors), which relies on certain findings in Milestone 4B (to identify EE technologies that have the greatest potential for reducing electricity consumption and GHG emissions in India, and to consider current sales patterns and other relevant parameters).

In particular, the technical potential for selected EE technologies in specific sectors – as estimated in work done under Milestone 4B – is used as a basis for deriving their economic and market potentials.

1.2 EE technologies under consideration

The analysis in Milestone 4B began with broad levels of EE technologies, as shown in Exhibit 2.1. The importance and relevance of these technologies was known from work done earlier by Nexant (eg. the USAID funded "Moving Markets for Energy Efficiency" Project) and others.[1]

[1] Refer to Report of Milestone 4B for a comprehensive review of available reports / other literature relevant to a technical potential assessment.

Exhibit 1.1: Broad level EE technology - sector combinations for assessment of technical potential

SNo.	*EE technology*	*Sector*
1	Lighting devices and accessories	Residential, Commercial, Industrial
2	Motors	Industrial, Commercial
3	Refrigeration	Industrial, Commercial
4	Heating, Ventilation and Air-Conditioning	Commercial

Refer to Milestone 4B report for rationale for selection of these broad level technologies.

These broad level EE technologies were narrowed down to more specific EE technologies – or generic product categories. Further work under Milestone 5A focuses on assessment of the economic and market potentials for these EE technologies (or generic product categories). To the extent necessary (and where data are available), the broad sectors have also been further narrowed down. Exhibit 1.2 shows the more focused EE technology - sector combinations.

Exhibit 1.2: EE technology / Generic product categories and sector / segment combinations for assessment of economic and market potentials

S.No	*EE technology / generic product category*	*Sector / segment*
1	CFL lamp	Residential: high consuming urban, other urban, rural
		Commercial - all
		Industrial - small / cottage LT, other LT, HT
		Public lighting, other
2	T8 lamp	Residential: high consuming urban, other urban, rural
		Commercial - all
		Industrial - small / cottage LT, other LT, HT
		Public lighting, other
3	EE electromagnetic ballast	Residential: high consuming urban, other urban, rural
		Commercial all
		Industrial - small / cottage LT, other LT, HT
		Public lighting, other
4	Electronic ballast	Residential: high consuming urban, other urban, rural
		Commercial - all
		Industrial - small / cottage LT, other LT, HT
		Public lighting, other
5	EE refrigerators	Residential: high consuming urban, other urban, rural
		Commercial - all
6	EE room air-conditioners	Residential: high consuming urban
		Commercial - all
7	EE motors	Residential: high consuming urban, other urban, rural
		Commercial - all
		Industrial - small / cottage LT, other LT, HT
		Public lighting, other

Note 1: The residential consumer segments that are considered were selected on the basis of tariff categories that are relevant to the assessment of economic and market potential. The high consumption segment refers to domestic consumers using more than 300 kWh per month, for which a high tariff applies to marginal consumption at that level. See discussion on nominal tariffs below.
Note 2: Only EE motors manufactured in India considered.

The methodology and assumptions for assessing the technical potential of these EE technologies / generic product categories are given in the Milestone 4B report. Only the results of the technical potential assessment exercise are summarized in this Milestone 5A report, along with requisite details for economic and market potential assessment.

2 The Approach for economic and market potential assessment

The following three-step approach is adopted:

- The first step involves assessment of *technical potential*, which is the potential energy savings from application of energy efficient technologies, where such applications are technically feasible. This analysis considers application limitations such as incompatibility of an existing lighting fixture with the EE lighting technology, or unsuitability of the EE product for specialized applications. The methodology and assumptions of the technical potential assessment are described in detail in the Milestone 4B report.

- The second step is to evaluate *economic potential*, which gives the portion of the technically feasible applications that produce sufficient savings to justify the additional cost of the EE option. The analysis considers the relative first cost of the existing and EE products, the economic benefits of features such as longer service lifetime of the EE product (reducing replacement costs), and the value of saved energy. Cost comparisons are made on a discounted basis to present value, developing a "cost of saved energy" for the EE option and comparing with: (1) the long run marginal cost (LRMC) of electricity which is taken as the opportunity cost of electricity from the national perspective, and (2) consumer tariffs, which are taken as the consumer's opportunity cost of electricity.

- The final step is to evaluate *market potential*, which is the estimate of ultimate penetration potential of the EE product. The assessment takes into consideration many market barriers that may be difficult or impossible to overcome and that limit the application of even very economically attractive applications of the EE option. Such barriers include consumer preferences, constraints in the supply of EE products due to local manufacturers and distribution channels, consumer financial constraints, and others.

The potentials for energy savings through various technologies, are estimated on the basis of energy consumption in various applications in 1999/2000 – in which the normal standard equipment / products are assumed to be replaced by the high efficiency options. Likewise, the impact of removal of financial and supply-chain constraints on the market potential is also assessed for the same year. No effort is made to project medium or long-term potentials.

2.1 Economic potential assessment

As mentioned above, from the technical potential assessments (as obtained from Milestone 4B report), the economic potential is addressed, that takes in to account the following:

- Whether or not the conversion to EE technologies (even if technically possible) makes economic sense from the national or society's perspective. The major issue that is considered here is the long run marginal cost (LRMC)[2]

[2] LRMC is the cost of supplying an additional unit (kWh) of electricity to utility customers over a time period that is sufficiently long so as to necessitate further investment.

- Whether or not the conversion to EE technologies (even if it is desirable from the national or society's perspective), would make sense to the individual electricity consumer. The two broad issues that are considered here are:
    - the stated (nominal) tariff rates, and
    - whether or not the customer actually pays for the electricity he consumes

Three key concepts are introduced here, neither of which is easily quantifiable – at least on an all India basis – as explained below. In fact, even on a state level basis, the necessary data are readily available only for stated tariff levels and structures for various customer categories. Further research and analysis (which is a large exercise and much beyond the scope of the present analysis) is required to obtain the necessary information on typical / average values as well as distributions (in a statistical sense from one state to another) of LRMC, average tariff rates per customer segment, and share of paying customers in each segment.

2.1.1 Long run marginal cost (LRMC)

LRMC estimates for Indian utilities are simply not available. The latest estimates are from the 1980's, and those too derived from an economic analysis type approach, rather than from analyses of utility's financial expenditures, performance and statements. In more recent times since the mid-1990's, with the beginning of power sector reform and restructuring programs in various states, even if (in the interest of transparency) a State Electricity Regulatory Commission (SERC) does desire that a basic LRMC exercise be carried out in its respective utility, it is not able to pursue this objective owing to severe data limitations. Some of the inadequacies of data required for LRMC computations are discussed in Annex 2.1.

Against this background, and with knowledge that LRMC in one state would in all likelihood be very different from another,[3] a very indicative broad-brush estimate for LRMC may be derived as follows:

- *Generation*: costs considered on the basis of power purchase tariffs that some utilities have negotiated with independent power producers (IPP's). Given that most IPP's are dual fuel fired (liquid fuel plus natural gas) combined cycle projects or liquid fuel fired diesel engine projects, their tariffs which are in the range of Rs 3.00 to 3.50 / kWh,[4] may be considered as a good indicator of marginal generation costs.

[3] For instance, certain states have large hydro projects and still have large untapped hydro potential (e.g. Himachal Pradesh, Assam, other north-Eastern states); while other states with little or not much more exploitable hydro potential are situated very far from coal fields (e.g. Tamil Nadu, Gujarat).

[4] This includes several IPP's which are either already operating (e.g. the naphtha - natural gas fired 208 MW combined cycle Spectrum Power project in Andhra Pradesh, the naphtha-natural gas fired 216 MW combined cycle GVK project in Andhra Pradesh, the LSHS fired 196 MW diesel engine GMR Vasavi Basin Bridge project in Tamil Nadu) or are under construction and nearing commercial operation date (e.g. gas fired combined cycle 330 MW PPN project in Tamil Nadu, the two LSFO fired 106 MW diesel engine Balaji Power and Sambalpatti Power projects in Tamil Nadu).

- *Transmission and distribution*: The GOI had recommended in 1980[5] that investment in generation should be matched by investment in transmission plus distribution. However, for two decades now, most state power utilities have routinely fallen behind this targeted investment level – and much more than 50% of the total power sector investment today would need to be for transmission and distribution in order to overcome the transmission and distribution capacity constraints. Further, given that (particularly) distribution is very manpower intensive, it may be assumed that the marginal cost of transmission and distribution is also in the same range as generation.

Thus estimated, the overall LRMC comes to about Rs 6 to 7 / kWh. For analytical purposes, the following assumptions are made:

- the LRMC of supply to rural areas should be considerably more (say Rs 7 - 8 / kWh)
- the LRMC of HT supply (to industrial customers) may in fact be only a little more than for generation alone, and may be considered as Rs 4 / kWh
- the LRMC of supply to other customers (residential urban, commercial etc.) may be considered as being in the Rs 6 - 7 / kWh range.

It so turns out that the economic potential assessments (presented in sections 4 through xxxxx for the various technologies under consideration) are not very sensitive to LRMC values – and that the broad-brush estimates should suffice.

2.1.2 Nominal tariff rates

The nominal tariff rates and structures also vary from one state to another, and average tariff rates on an all-India basis are difficult to compute for the various customer categories. Furthermore, even within one sector (e.g. industrial or residential), there are several segments – and the segments are defined differently in the various states. By way of an illustration, Annex 2.2 gives the tariff categories and tariff rates as applicable in one state (Tamil Nadu).

Nevertheless, it is possible to combine some tariff categories (or segments), in order to compare the tariff levels prevailing in the various states. For analytical purposes, certain broad segments are considered. Exhibit 3.1 shows these segments as well as the average tariff rates considered for analytical purposes. Annex 3.3 provides the basis for the average tariff rates across the various utilities for one such segment (the urban high consumer).[6] Similar data for other customer categories and segments are also available.

---

5 Refer to Government of India, Report on the Committee of Power (Committee set up under the chairmanship of Mr. Rajadhyaksha), New Delhi, 1980.

6 For analytical purposes, it is assumed that the urban high consumer in the residential sector has a monthly consumption of 300 kWh or more, and the tariff is about Rs 3 / kWh. This is much in line with the tariff regime prevailing in seven private utilities, whose highest consumption category varies between >200 kWh and >500 kWh; and the highest tariff level is between Rs 2 to Rs 4 / kWh for five of the seven private utilities. Likewise, in 17 of the 26 states, the highest consumption slab is between >200 kWh and >500 kWh, and the highest tariff is between Rs 2 to Rs 4 / kWh for 12 of the 17 states, is above Rs 4 / kWh for two states, and below Rs 2 / kWh for three states.

Exhibit 2.1: Average tariff rates assumed for various customer segments

Sector	*Segment*	*Tariff (Rs / kWh)*
Residential	Urban High consumer	3.00
	Urban Low consumer	0.70
	Rural	0.70
Commercial	All	3.00
Industrial	Cottage / Small LT	2.20
	Other LT	3.30
	HT	3.00
Other	Public lighting	1.60
	Other	1.60

Source: Refer to Annex 2.2

Although the average tariff levels given in Exhibit 2.1 may be debated, they should suffice our purpose of an economic potential assessment – and the results so obtained are sufficiently robust over a wide range of tariff assumptions.

These tariff levels however, are not static, and would change in the coming years. While SERC's and state utilities would be the major players involved in the tariff setting exercise in their respective states, certain trends however can be deciphered. These trends may well be quite different from the following that have been witnessed in the past two decades (when the utilities tried to comply with the state Government's social objectives that were not entirely consistent with the stipulated 3% return on net fixed assets):[7]

- continued high subsidy / free power to agricultural consumers and hut dwellers
- subsidized supply to low income residential customers
- partial cross subsidization from other customer categories – mostly HT industrial and commercial customers, but also LT industrial customers (other than small / cottage / tiny industrial establishments)
- dependence on the state Government for "revenue subsidy" to meet the stipulated rate of return objectives

Future trends of tariff changes would be expected to be as follows:

- Continued real term and sharp increases in HT and LT industrial and commercial tariffs would most likely not continue, as these utility customers would / are already beginning to find it increasingly cost-effective to switch to captive generation.[8] An increase in nominal tariffs in line with inflation rates – or in line with diesel prices – would be more likely.

7 As per the Electricity (Supply) Act, 1948.

8 Mostly from high-speed-diesel (HSD) fired diesel gensets.

- Considering that the only other sector / segment that can fill the void thus left is the high income residential sector – it may be that for a few years at least, the highest consumption households experience sharp and real term increases in tariffs in the highest consumption slab (defined in most states as >200 to >500 kWh / month). However, this also may not continue for long either – and for the same reasons.

- The subsidized categories, would come under increasing pressure to pay for the power they consume.

It is evident therefore, that even if the technical potential for energy savings were to remain unchanged (from the 1999/2000 level) in the coming years, the economic potential would:

- Either increase, particularly for customer segments whose nominal tariffs escalate faster than inflation rates

- Or at most remain unchanged for certain customer segments whose nominal tariff rates rise essentially in line with inflation.

2.1.3 Who pays the tariffs

Whether or not customers actually pay for the power they consume has always been a sensitive issue in India. For several decades, the various state level power utilities – the state electricity boards (SEB's) – officially stated that their total T&D losses were in the range of 20 - 22%. That their actual T&D losses were – and remain – much higher is now generally accepted. For instance, all the reforming utilities (of Orissa, Andhra Pradesh, Haryana, Rajasthan etc.) have now conceded that their total T&D losses are substantially higher – as high as 35-40% or even more!

High non-technical losses (owing to pilferage by authorized customers and tapping overhead lines by unauthorized consumers coupled with the inability to disconnect such consumers, meters that have stopped working but are not replaced, meters that slow down over the years that have not been recalibrated, as well as deliberate under-reading of meters through a collusion of "corrupt" meter readers / distribution personnel and customers) are now accepted as the principal reason for such high loss levels.

Poor energy accounting practices in all utilities also means that no utility has a reasonably good idea of the level of non-technical losses in each customer category or segment. Against this background, the segment share that actually pays the nominal tariffs remains a matter of conjecture. For analytical purposes, the share of each customer segment that is assumed to pay the nominal tariff is as shown in Exhibit 2.2. This assumption may be considered reasonable on account of (among other) the following:

- pilferage and theft is non uncommon either in rural or urban areas – and in residential, commercial and industrial establishments

- disconnection of unauthorized customers (that may be residential, commercial or even if small / cottage industrial category) has been (until now) virtually impossible

- many utilities acknowledge that government / public lighting / other general category customers do not pay for the power they consume

Exhibit 2.2: Share of customer segment paying the nominal tariff

Sector	*Segment*	*% share paying nominal tariff*
Residential	Urban High consumer	90
	Urban Low consumer	80
	Rural	60
Commercial	All	75
Industrial	Cottage / Small LT	75
	Other LT	75
	HT	90
Other	Public lighting	50
	Other	50

2.2 Market potential assessment

An explicit consideration of market constraints and their implications on the reduction of economic potential is useful in the design of national EE promotional programs, as well as the consideration of market interventions to reduce barriers (e.g. awareness promotion, financial incentives, trade ally initiatives, EE standards). For analytical purposes therefore, the reductions to the economic potential (and the consequent market potential) are considered for the following three broad scenarios:

- *With all market constraints, as at present*: In this scenario, the impact of various market barriers on translation of economic potential to market potential is assessed. The market barriers considered are consumer awareness (assuming suitable promotional programs are successfully implemented), compatibility of the technology with consumer needs and increasing consumer sophistication, product availability constraints due to problems in the supply chain, financial problems / constraints that impede investment in EE products / technologies and accord a low priority on such up-front expenditure etc.

- *With maximum relief of financial constraints*: In this scenario, it is assumed that to the extent any EE technology displays economic potential for energy savings from a national perspective, the GOI would offer all necessary fiscal and financial measures to promote it. It needs no reiteration that a successful implementation of such programs would be necessary.

- *With relief of supply chain constraints*: In this scenario, it is assumed that to the extent the penetration of any EE technology is impeded due to supply-chain barriers and problems, the necessary steps would be / can be / are taken to overcome them.

A comparison of the market potential assessed in the three scenarios gives the extent to which suitable intervention is possible.

Surveys of consumers and stakeholders in the supply chain have generally not been undertaken or have been very limited toward evaluating market barriers quantitatively. Necessarily therefore, these market constraint factors are judgmental – and being different for the specific technologies under consideration, are discussed in the respective sections (4 through 10). They represent real constraints that are expected in the marketplace, and for any specific EE product indicate relative differences in severity of constraints among consumer segments. Such an analysis is conducive to consideration of alternative assumptions and their impacts on the market potential results. Suitable sensitivity analyses however, indicate a certain measure of robustness of the results.

2.3 Discount rates

The discount rates used for economic potential assessment are shown in Exhibit 2.3. The basis for using these discount rates for analytical purposes is as follows:

- The GOI's Planning Commission normally uses an annual discount rate of 12% for its economic appraisal of investment projects. Given that HT customers are large projects, and public lighting and other categories would not be "commercial or private" enterprises, this same 12% discount rate is assumed

- In line with this, the discount rates for other "private" customer categories should be somewhat higher – the highest being for the rural residential and urban low consumers.

Exhibit 2.3: Discount rates by customer segment

Sector	*Segment*	*Discount rate (%)*
Residential	Urban High consumer	15
	Urban Low consumer	20
	Rural	20
Commercial	All	15
Industrial	Cottage / Small LT	15
	Other LT	15
	HT	12
Other	Public lighting	12
	Other	12

3 Compact Fluorescent Lamps

3.1 *Segment share of existing light points*

Compact fluorescent lamps (CFL's) are considered for replacement of existing incandescent (general lighting system or GLS) lamps – provided it is technically feasible, in the sense that the existing GLS base and fixture are compatible with the CFL. The Milestone 4B report gives details of the basis and assumptions used to estimate the total number of GLS light points in the four broad customer categories, where it is technically feasible to switch to CFL's. This is further split between various segments as shown in Exhibit 4.1, on the following basis:

- Residential sector: As per a national survey conducted by NCAER, 59% of all light points in the residential sector are in urban areas. For analytical purposes, it is assumed that this share holds for both GLS lamps and FTL's. About 1% of the light points (i.e. both GLS and FTL's) are assumed to be in high consumption categories (consuming > 300 kWh per month).[9]

- Commercial sector: No further segmentation is considered for analytical purposes

- Industrial sector: No relevant information for any type of industrial sector segmentation is available. However, the assumption of 50:30:20 in the three industrial segments under consideration may be considered reasonable, and given the small number (only about 6 million light points) is not likely to introduce any significant error.

- Other sectors: The only information available is from the ACEEE report published in 1991. For analytical purposes, the same ratio of public lighting to other categories is assumed. Again, given the small number (about 4.5 million light points only), this assumption is not likely to introduce any significant error.

[9] This is broadly assessed as follows: a monthly consumption of 300 kWh (i.e. daily consumption of 10 kWh), can not be reached only with light bulbs, fans, refrigerators and TV's. It is necessary for the household to also use other electric appliances, particularly those with a high wattage rating which are used for several hours in a day. It is clear that this calls for items like air-conditioners, and perhaps geysers. Given the population of such type of electrical gadgets, it is assessed that only about 1% of households would reach the 300 kWh / month consumption level.

Exhibit 3.1: Technically feasible number of GLS light points for conversion to CFL – by customer segment

Sector	*Segment*	*%*	*Number (millions)*
Residential	Urban High consumer	1	2
	Urban Low consumer	58	125
	Rural	41	89
	All	100	216
Commercial	All	100	13
Industrial	Cottage / Small LT	50	2
	Other LT	30	1
	HT	20	1
	All	100	5
Other	Public lighting	58	3
	Other	42	2
	All	100	5
All			238

Source: NCAER (1998), ACEEE (1991)

3.2 Technical potential

The technical potential for annual energy savings is summarized in Exhibit 3.2, and along with assumptions / inputs / consistency checks etc., is detailed in the Milestone 4B report. For analytical purposes, the following input data and assumptions are used:

- there are a total of about 300 million existing light points for GLS' in all sectors
- about 80% of GLS light points can be possibly converted to CFL's in the residential, industrial and other sectors, while about 70% can be converted in the industrial sector[10]
- one GLS lamp (of average 70 watt rating) is assumed to replace one CFL (of average 21 watt) rating, thereby leading to savings of 49 watts per light point
- average annual operating hours and annual utilization factor[11] per light point vary from sector to sector, as shown in Exhibit 3.2
- after conversion to CFL's, there would be no significant change in annual operating hours and annual utilization factors

[10] The cap / base size of all incandescent lamps (from 0 to 100 watts) is the same, and in general there may be no compatibility problems for conversion to CFL's. The only incompatibility may be where the existing fixture / shade / luminaire can not be used to house the somewhat longer CFL. Against this background, it may be conservatively estimated that about 80% of all GLS sites can be converted to CFL's. In the commercial sector however, where there are specific applications (e.g. Dimming applications, focused lighting etc.), the overall compatibility may be somewhat less – and is again conservatively assumed that about 70% of GLS sites in the commercial sector can be converted to CFL.

[11] Annual operating hours refers to a standard average number of operating hours per light point. However, in reality, some lamps may not be in use for a limited period as extra lamps are fitted (which are not included in the light point count), or in some cases, when lamps are not replaced for a certain number of days even when they stopped working.

Exhibit 3.2: CFL's - Technical potential for energy savings

Sector / segment	*Light points (millions)*		*Utilization factor (%)*	*Operating hours / year*	*Energy savings (GWh / year)*
	Total	*Tech. Feasible conversion*			
Residential	270	216	75	1400	11,113
Commercial	18	13	60	3000	1,111
Industrial	6	5	90	3000	635
Others	6	5	83	4000	776
All	300	238			13,636

Source: Milestone 4B report

3.3 Economic potential

In addition to the various assumptions highlighted in section 2 and Exhibit 2.1, the other key assumptions include:

- unit GLS lamp price of Rs 10;[12]
- unit price of the equivalent CFL as Rs 560;[13]
- useful economic life of a GLS lamp is taken as 435 hours for residential consumers and 667 hours for other consumers;[14] and
- useful economic life of a CFL is taken as 5000 hours.[15]

The results of economic analyses are presented in Exhibit 3.3, and detailed in Annex 3.1.

The life-cycle cost of saved energy, which is the effective benefit (avoided cost) to society of "deemed" additional generation resulting from conversion of GLS lamps to CFL's, is in the range of Rs 2.5 to 4 / kWh. This is used as a basis for the following three estimates of economic potential shown in Exhibit 3.3:

- one, where for each customer segment, the life-cycle cost is compared to LRMC (which may be considered as the opportunity cost). Where the LRMC is higher than the life-cycle cost, the economic potential is considered to exist, and equals the technical potential. Given that the LRMC costs are very high, the economic potential so computed equals the technical potential.

- second, where for each customer segment, the life-cycle cost is compared to the actual nominal tariff (which is now considered as the opportunity cost). Where the tariff rate exceeds the life-cycle cost, the economic potential is considered to exist, and equals the technical potential. In this case economic potential for energy savings is considerably reduced to a little over 300 GWh / year.

- economic potential would reduce further, if the ground reality – that not all registered customers actually pay for the power they consume – is considered. In this situation, the economic potential for savings through conversion to CFL's reduces further just over 250 GWh per year.

---

12 Retail price, inclusive of all taxes and duties. In rural areas, the average price was taken as Rs 5, due to the prevalence of low-quality lamps which can cost as little as Rs 2.5.

13 Retail price of a Phillip CFL, inclusive of all taxes and duties, as well as distributor / wholesaler and retailer margins. Most manufacturers import certain components of CFL's and assemble in India. The import duty on CFL components is 35% -- as is for the imported CFL itself. It is because of this high import duty level that the illegally imported (and in any case, not as expensive, but also relatively low quality) Chinese CFL's are posing a problem to other manufacturers / assemblers / importers.

The lower priced CFL has a correspondingly lower economic life, some below 1,000 hours. Sensitivity analysis on the price and expected lifetime indicated that the economic potential changes little if low quality CFL lamps are assumed rather than high quality lamps, due to the impact of service life.

14 This represents the weighted average useful life for GLS lamps sold in urban / industrial and rural areas.

15 See footnote 13.

Exhibit 3.3: CFL's – Economic potential for energy savings

Sector	*Segment*	*Unit energy savings (kWh / yr)*	*Life cycle cost of saved energy (Rs / kWh)*	*Economic Potential (GWh / year) assuming*		
				LRMC as Opportunity cost	*Current Tariff as Opportunity cost*	*Actual tariff payment as Opportunity cost*
Residential	Urban High consumer	51.45	3.31	111	-	-
	Urban Low consumer	51.45	3.63	6446	-	-
	Rural	51.45	3.96	4556	-	-
Commercial	All	88.20	3.81	1111	-	-
Industrial	Cottage / Small LT	132.30	2.54	318	-	-
	Other LT	132.30	2.54	191	191	143
	HT	132.30	2.47	127	127	114
Other	Public lighting	161.7	2.62	452	-	-
	Other	161.7	2.62	324	-	-
All				13,636	**318**	**257**

Note: By way of an illustration to show the robustness of the results obtained, relevant data pertaining to a poor quality GLS lamp (manufactured by small industrial enterprises with little or no quality control procedures in place) that is often found in rural areas is considered. In particular, the unit GLS lamp price is taken at Rs 2.50, and the useful like at 100 hours (which is in line with the reported fact that these lamps need to be changed every few weeks – or at most a month or two). Even with these assumptions, the economic potential in the rural residential segment remains unchanged from the level shown above.

3.4 Market potential

The market potential for CFL lamps indicates the severe limitations on marketability represented by the high first cost of lamps, despite the potential societal benefits indicated by economic potential using LRMC as a comparison standard. Considerations represented by assumptions on various constraints / barriers are indicated below:

- *Consumer awareness*: It is generally assumed that the indicated awareness levels can be achieved through market promotion. Consumers with very low tariffs, and those that do not pay for electricity, are assumed to be relatively less sensitive / responsive to / and less interested in messages about energy conservation benefits of any particular product.

- *Consumer application compatibility*: Generally, application compatibility refers to the portion of available CFL's that satisfy consumer preferences as a suitable replacement for the existing GLS fixture, in terms of color rendition, aesthetics, and operational issues (such as requirement for instant starting capability and short-usage applications). The most severe compatibility issues are expected in the urban high consumption categories, where aesthetics and prevalence of short-usage applications are relevant.
- *Availability due to supply chain constraints*: CFL lamps are already available in urban areas, and supply chain constraints are not expected to be important in these areas if demand increases. In particular, segments that could buy CFL's in large quantities (industrial, commercial, public lighting etc.) should not face such constraints. However, rural consumers are expected to face relatively larger supply

chain constraints, particularly to the extent that distributors do not perceive there is a market in rural areas. GLS producers in the unorganized sector may also be expected to resist the prospect of losing market share to CFL's where they can, and put pressure on distributors.

- *Financial constraints*: From a practical and operational point of view, many consumers face greater financial constraints than is suggested by the 12% / 15% / 20% discount rates assumed in assessing the economic potential. For some, the implied discount rate they use in purchase decisions does not appear rational compared to their available resources, but may reflect other realities or inefficiencies inherent in their budgeting process, over which they have little or no control.[16] Without consumer survey data, it is difficult to assess the extent or severity of financial constraints, though they are typically considerable. In the absence of survey data, assumptions should be reviewed and debated to arrive at consensus values. It may also be noted that financial constraints may be alleviated to varying degrees through market interventions such as consumer rebates, installment payment programs, manufacturer incentives, etc.

The results clearly show that owing to the large up-front cost of CFL's, one of the best ways to push for CFL use is through a well-structured and targeted system of incentives that help the buyers to overcome their concerns of high initial costs.

Exhibit 3.4: CFL's – Market potential for energy savings

Sector	*Consumer awareness (%)*	*Consumer application compatibility (%)*	*Avail. due to supply / chain constraints (%)*	*Consumers with finance constraints (%)*	*Market potential (GWh / year)*		
					With all existing market constraints	*With Max relief of financial constraints*	*With relief of supply / chain constraints*
Residential							
- Urban high consumer	90	30	100	50	-	30	-
- Urban, other	70	90	100	100	-	4061	-
- Rural	60	90	10	100	-	246	-
Commercial							
- All	90	70	90	50	-	630	-
Industry							
- Cottage / small LT	80	70	80	50	-	142	-
- Other LT	80	70	90	50	36	96	40
- HT	90	70	100	50	36	80	36
Other							
- Public lighting	90	100	100	100	-	306	-
- Other	90	100	100	100	-	219	-
Total					**72**	5984	**76**

[16] For instance, many industrial and other consumers have indicated that effectively they have no budget for EE purchases, and have a fixed operating budget for commodity purchases (e.g. lamp replacements). At least in theory therefore, they would require essentially 100% return so that the additional cost is paid back in savings in one year. Many customers would thus require short payback periods.

In summary, CFL's represent one of the largest opportunities for energy savings in terms of technical potential, as replacements for a large portion of existing GLS lamps. Their cost of saved energy is less than the LRMC and hence from a societal perspective, the typical CFL replacement opportunity is economic as well as the economic potential is high.

However, due to the first high cost of CFL lamps and the low tariff faced by the majority of GLS users (potential CFL purchasers), economic potential from the consumer perspective is about 20% of that from the national perspective. This EE option will require considerable financial assistance to realize its potential. Such assistance may be applied as direct consumer financial help in a variety of forms, manufacturer incentives to reduce costs, or distributor incentives.

Market barriers reduce CFL economic potential further, to the extent that without intervention efforts (particularly on the financial aspects), market potential is assessed at an amount less than several other lighting EE options. One important factor is that for many customer segments that have relatively high economic potential, CFL lamps are not suitable replacements in many applications, whereas, such barriers are much less in the lowest income and rural domestic segments where market potential would be high if financial barriers can be overcome.

4 T8 Lamps

4.1 Segment share of existing light points

T8 lamps are considered for replacement of the standard fluorescent tube light (FTL) – provided it is technically feasible. Given that FTL's and T8's are of the same standard length, it is conservatively assumed that about 90% of FTL's can be replaced by T8 lamps. This ratio is assumed across all customer segments for analytical purposes.

The basis and assumptions for estimating the total number of FTL light points for the four broad customer categories, where it is technically feasible to convert to T8's, are given in the Milestone 4B report. This is further split between the various segments as shown in Exhibit 4.1, on the following basis:

- About 10% of FTL light points have already been replaced with T8 lamps. Therefore, the numbers shown in Exhibit 4.1 refer to 90% of the remaining 90%.
- In the residential and industrial sectors, the share of FTL light points in the various segments is as per those for GLS lamps (refer to section 3.1 and Exhibit 3.1). In the commercial sector, no further segmentation is considered for analytical purposes.
- In the other sectors, information available from the ACEEE report published in 1991 forms the basis for the shares of the two segments considered – as no further updates are available.

Exhibit 4.1: Technically feasible number of FTL light points remaining for conversion to T8 – by customer segment

Sector	*Segment*	*%*	*Number (millions)*
Residential	Urban High consumer	1	1
	Urban Low consumer	58	36
	Rural	41	25
	All	100	62
Commercial	All	100	61
Industrial	Cottage / Small LT	50	11
	Other LT	30	7
	HT	20	4
	All	100	22
Other	Public lighting	39	4
	Other	61	6
	All	100	10
All			154

Source: NCAER (1998), ACEEE (1991)

4.2 Technical potential

The technical potential for annual energy savings is summarized in Exhibit 5.2. The detailed approach for technical potential estimation is given in the Milestone 4B report. For analytical purposes, the following input data and assumptions are used:

- there are a total of a little over 190 million FTL points in all sectors, of which 10% have already been converted to T8 lamps, and 90% of the remainder can be conservatively considered to be converted to T8 lamps

- one FTL (of 40 watts) is assumed to replace one T8 lamp (of 36 watts), both using the same 15 watt electromagnetic ballast – thereby leading to a savings of 4 watts per light point

- average annual operating hours and annual utilization factor per light point vary from sector to sector, as shown in Exhibit 4.2

- after conversion to T8, there would be no significant change in annual operating hours and annual utilization factors, also shown in Exhibit 4.2

Exhibit 4.2: T8 lamps - Technical potential for energy savings

Sector / segment	*Light points (millions)*		*Utilization factor (%)*	*Operating hours / year*	*Energy savings (GWh / year)*
	Total	*Tech. Feasible conversion*			
Residential	76	62	75	1400	311
Commercial	75	61	60	3000	437
Industrial	27	22	90	3500	276
Others	12	10	83	4000	127
All	190	154			1,150

Source: Milestone 4B report.

4.3 Economic potential

In addition to the various assumptions highlighted in section 3 as well as those for assessing the technical potential, are the following other key assumptions:

- unit FTL price is Rs 40

- unit T8 price is Rs 39

- useful economic life of both is about 3000 hours

Given the fact that the more efficient T8 has the same useful economic life as the conventional FTL, and is also priced lower in the market, it is safe to consider that the economic potential for energy savings (from FTL to T8 conversion) is the same as the technical potential. Exhibit 4.3 shows the economic potential by customer segment.

Exhibit 4.3: T8 lamps – Economic potential for energy savings

Sector	*Segment*	*Unit energy savings (kWh / yr)*	*Economic potential (GWh / year)*
Residential	Urban High consumer	5.0	3
	Urban Low consumer	5.0	180
	Rural	5.0	127
Commercial	All	7.2	437
Industrial	Cottage / Small LT	12.6	138
	Other LT	12.6	83
	HT	12.6	55
Other	Public lighting	13.2	50
	Other	13.2	77
All			**1150**

4.4 Market potential

Likewise, it is safe to assume that any customer (no matter what sector or segment) that can afford to use FTL's, can most certainly afford the T8. The market potential for the T8 would be different from its economic potential only to the extent that:

- the customers are not fully aware the (still relatively new)
- the customer is sophisticated enough to be concerned about factors like aesthetics etc.
- the T8 is not readily available

Exhibit 4.4 presents the estimated market potential considering such criteria. Assumptions regarding the various market barriers are described below:

- *Customer awareness*: Customer awareness in the long run will depend upon marketing by distributors. This is because although T8 lamps are visibly different from the standard FTL's due to their smaller diameter, in other respects they are not apparently different, and in time many consumers do not differentiate them. In practice, the savings potential at 10% is not so great as to create significant market pull for T8 technology. Nevertheless, customer awareness is not viewed as a significant market barrier in most segments except in rural areas, where awareness related promotion may be expected to be little and consumers have more limited choice and are subject to product availability from distributors

- *Customer application compatibility*: This also represents a very minor market barrier for T8 lamps. From a market perspective, application compatibility issues are due largely to issues regarding availability of colors, color rendition, and other features compared to the available product lines of existing lamps. This barrier may be essentially eliminated if manufacturers switch production to T8 and make all features available in the T8 lamp.

- *Supply chain constraints*: The principal barrier to the T8 lamp availability is the extent that manufacturers are willing to make the investment to modify their production lines. In some countries (e.g. Thailand), manufacturers have made almost a complete transition in a relatively short time of 10 years. Other countries (e.g. USA) have not, despite significant market intervention efforts, and do not have the prospect of doing so in the near future. In India, supply chain constraints have been assumed to be slight, because there are a few FTL product lines, and that it should not be difficult for manufacturers to make the switch – although it may require some investment. However, smaller manufacturers may be reluctant or unable to do so, and as demand is not expected to be highly sensitive to T8 vs existing lamps, this market barrier may be much greater than assumed – unless standards are imposed by the Government

The following additional observation on the results presented in Exhibit 4.4 merit attention: The market potential with maximum relief of financial constraints is different from that with all existing market barriers only to the extent that energy savings from certain consumers who do not pay for the power they consume is also included. And given the rather small difference between the two (about 180 GWh, albeit 40%), it is clear that the impact of financial incentives that the GOI may offer through any programmatic interventions may only be limited.

Exhibit 4.4: T8 lamps – Market potential for energy savings

Sector	*Consumer awareness (%)*	*Consumer application compatibility (%)*	*Avail. due to supply / chain constraints (%)*	*Consumers with finance constraints (%)*	*Market potential (GWh / year)*		
					With all existing market constraints	*With Max relief of financial constraints*	*With relief of supply / chain constraints*
Residential							
- Urban high consumer	80	90	90	50	2	2	2
- Urban, other	70	90	90	100	82	102	91
- Rural	60	90	90	100	25	41	41
Commercial							
- All	80	90	90	50	212	283	236
Industry							
- Cottage / small LT	80	90	80	50	60	80	75
- Other LT	80	90	90	50	40	54	45
- HT	80	90	90	50	32	36	35
Other							
- Public lighting	80	90	90	100	16	32	18
- Other	80	90	90	100	25	50	28
Total					**494**	**680**	**571**

In summary, T8 lamps offer an excellent opportunity for energy savings -- despite their relatively low unit potential of 10% -- because market barriers are less than they are for other options. At the same time, it is difficult to create significant market pull as an impetus for market transformation, because consumers do not differentiate the T8 from the standard FTL well, although this may be an important initial step to market conditioning and raising interest among manufacturers. The experience of some other countries shows that market push initiatives, such as product standards, have been more successful in terms of reducing market barriers.

5 EE Electromagnetic ballast

5.1 Segment share

The EE Electromagnetic (EM) ballast is considered for replacement of the standard EM ballast in FTL connections. Conversion to the EE-EM ballast should be 100% technically feasible. The market penetration of the EE-EM ballast however, has been negligible so far. Exhibit 5.1 shows the total number of conversion sites that are technically possible.

Exhibit 5.1: Technically feasible number of EE-EM ballasts, by customer segment

Sector	*Segment*	*%*	*Number (millions)*
Residential	Urban High consumer	1	1
	Urban Low consumer	58	44
	Rural	41	31
	All	100	76
Commercial	All	100	75
Industrial	Cottage / Small LT	50	14
	Other LT	30	8
	HT	20	5
	All	100	27
Other	Public lighting	39	5
	Other	61	7
	All	100	12
All			190

Source: NCAER (1998), ACEEE (1991)

5.2 Technical Potential

The technical potential for annual energy savings is summarized in Exhibit 5.2. For analytical purposes, the following assumptions (which are explained in detail in the Milestone 4B report) are made:

- one EE-EM ballast (of 9 watts) is assumed to replace one standard EM ballast (of 15 watts) – thereby leading to a savings of 6 watts per light point
- the average annual operating hours and annual utilization factors per light point (as shown for the various sectors in Exhibit 5.2) do not change significantly after the conversion to the EE-EM ballast

Exhibit 5.2: EE-EM ballast - Technical potential for energy savings

Sector / segment	*Light points (millions)*		*Utilization factor (%)*	*Operating hours / year*	*Energy savings (GWh / year)*
	Total	*Tech. Feasible conversion*			
Residential	76	76	75	2000	575
Commercial	75	75	60	3000	810
Industrial	27	27	90	3500	511
Others	12	12	83	4000	234
All	190	190			2,130

Source: Milestone 4B report.

5.3 Economic potential

In addition to the various assumptions highlighted in section 3 as well as those for assessing the technical potential, are the following other key assumptions for economic potential assessment:

- the price of a standard EM ballast is Rs 50, and its useful life is about 2,500 hours. This is the price of a normal, standard EM ballast that is commonly available in India. It is manufactured in the small / tiny / cottage sector (and is reserved by the GOI for manufactured in this segment of industry), is generally of poor quality, and generally does not last for more than an year.[17]

- The price of the EE-EM ballast price is about Rs 200 (inclusive of all taxes, duties, distributor margins etc.). Such ballasts may have a useful life of as much as 10,000 hours.[18]

On the basis of these assumptions, the life-cycle cost of saved energy is computed and compared with an "opportunity cost" to arrive at the economic potential of energy savings from EE-EM ballasts. The results are shown in Exhibit 5.3, and may be summarized as follows:

- given that the opportunity costs presented by the LRMC would be substantially higher than the cost of saved energy, the economic potential would equal the technical potential

- however, given that some of the customer categories have subsidized tariffs (notably the low / middle income urban households and rural households), the economic potential gets reduced to the extent EE-EM ballasts do not remain attractive to such consumers. The analysis shows a reduction of about 20% in the energy savings potential

- furthermore, as not all customers pay for the electricity they consume, the economic potential (from the end-users' perspective) falls further short of the technical potential, and is estimated at a little over half of the technical potential.

[17] However, there are significant variations in the quality and price of standard EM ballasts produced in the small / tiny / cottage (i.e. unorganized) sector as well. The best quality of ballasts from such manufacturers cost some Rs 80, and may last somewhat longer. The standard EM ballasts branded by larger enterprises (but still manufactured by small scale units) are still more expensive at about Rs 150 per unit, but have a useful life of as much as 10,000 hours. Such branded standard EM ballasts however, are reported to be less than 1% of the market share.

[18] In fact, the EE-EM ballasts are normally manufactured by the larger enterprises – or rather, by the smaller units that have some links with the larger enterprises.

Exhibit 5.3: EE-EM ballasts – Economic potential for energy savings

Sector	*Segment*	*Unit energy savings (kWh / yr)*	*Life cycle cost of saved energy (Rs / kWh)*	*Economic Potential (GWh / year) assuming*		
				LRMC as Opportunity cost	*Current Tariff as Opportunity cost*	*Actual tariff payment as Opportunity cost*
Residential	Urban high consumer	7.6	1.66	6	6	6
	Urban Low consumer	7.6	2.31	334	-	-
	Rural	7.6	2.31	236	-	-
Commercial	All	10.8	1.10	810	810	607
Industrial	Cottage / Small LT	18.9	0.62	256	256	192
	Other LT	18.9	0.62	153	153	115
	HT	18.9	0.49	102	102	92
Other	Public lighting	19.8	0.47	92	92	46
	Other	19.8	0.47	143	143	71
All				2130	1561	1128

5.4 Market potential

The market potential for EE-EM ballasts is shown in Exhibit 5.4.

Exhibit 5.4: EE EM ballasts – Market potential for energy savings

Sector	*Consumer awareness (%)*	*Consumer application compatibility (%)*	*Avail. due to supply / chain constraints (%)*	*Consumers with finance constraints (%)*	*Market potential (GWh / year)*		
					With all existing market constraints	*With Max relief of financial constraints*	*With relief of supply / chain constraints*
Residential							
- Urban high consumer	80	100	10	50	-	-	2
- Urban, other	70	100	10	100	-	23	-
- Rural	60	100	10	100	-	14	-
Commercial							
- All	80	100	10	50	49	65	486
Industry							
- Cottage / small LT	80	100	10	50	15	20	153
- Other LT	80	100	10	50	9	12	92
- HT	80	100	10	50	7	8	74
Other							
- Public lighting	80	100	10	100	4	7	37
- Other	80	100	10	100	6	11	57
Total					90	162	901

The principal barriers to market penetration pertains to the supply chain constraint. Small / tiny / cottage sector manufacturers have nearly the entire market share for existing standard EM ballasts. Given that EE-EM ballasts would require superior quality production methods, better quality control etc., it is important that:

- either production methods followed by the small / tiny manufacturers be suitably upgraded, and that appropriate quality assurance / quality control norms are instituted

- or suitable legislative changes be made to de-reserve ballast production from small / tiny / cottage units.

Other barriers may not be as important. In particular:

- *Consumer awareness.* Consumer awareness is not expected to be a significant barrier, as consumer choice is generally expected to be influenced by availability from distributors. If most consumers are expected to be price sensitive over other considerations, some mechanism may need to be developed so as to educate the consumer about benefits over product life cycle.

- *Consumer application compatibility.* This does not present a barrier

- *Financial constraints.* This does not represent a significant barrier. Our analysis shows the relatively little impact that GOI's fiscal / financial policy initiatives can possibly have on the market penetration of EE EM ballasts.

6 Electronic Ballast

6.1 Segment share

The electronic ballast is considered for replacement of the standard EM ballast in FTL connections. However, owing to incompatibility in the design of existing fittings and fixtures, it may not be possible to retrofit all FTL's with electronic ballasts. The compatibility levels are expected to be:

- about 75% in the commercial sector
- about 90% in the industrial and other sectors
- an intermediate level (about 80%) in the residential sector

Nevertheless, the market penetration of the electronic ballast has been negligible so far. Exhibit 6.1 shows the total number of conversion sites that are technically possible.

Exhibit 6.1: Technically feasible no. of Electronic ballasts, by customer segment

Sector	*Segment*	*%*	*Number (millions)*
Residential	Urban High consumer	1	1
	Urban Low consumer	58	35
	Rural	41	25
	All	100	61
Commercial	All	100	56
Industrial	Cottage / Small LT	50	12
	Other LT	30	7
	HT	20	5
	All	100	24
Other	Public lighting	39	4
	Other	61	6
	All	100	11
All			152

Source: NCAER (1998), ACEEE (1991)

6.2 Technical potential

Details regarding the various assumptions and inputs for technical potential estimation are presented in the Milestone 4B report. The various assumptions may be summarized as follows:

- one electronic ballast (of 2 watts) replaces one standard EM ballast (of 15 watts), thereby leading to a savings of 13 watts

- the average annual operating hours and annual utilization factors per light point (as shown for the various sectors in Exhibit 6.2) do not change significantly after the conversion to the EE-EM ballast

The technical potential for savings thus projected is shown in Exhibit 6.2.

Exhibit 6.2: Electronic ballast - Technical potential for energy savings

Sector / segment	*Light points (millions)*		*Utilization factor (%)*	*Operating hours / year*	*Energy savings (GWh / year)*
	Total	*Tech. Feasible conversion*			
Residential	76	61	75	2000	997
Commercial	75	56	60	3000	1,315
Industrial	27	24	90	3500	997
Others	12	11	83	4000	457
All	190	152			3,766

Source: Milestone 4B report

6.3 Economic potential

In addition to the various assumptions highlighted in sections 3, 7.1 and 7.2, the other key assumptions used for economic analysis are:

- the price of a standard EE-EM ballast and its useful economic life are Rs 50 and 2500 hours respectively (see section 4.3 for further details)
- the price of an electronic ballast is Rs 330 and its useful life about 10,000 hours[19]

On the basis of these assumptions, the life-cycle cost of saved energy is computed and compared with various / certain measures of "opportunity cost" to arrive at the economic potential of energy savings from electronic ballasts. The results as shown in Exhibit 6.3 are as follows:

- as the LRMC in all customer segments is substantially higher than the life cycle cost of saved energy, the economic potential from the national perspective equals the technical potential in all customer segments.
- the picture changes somewhat if nominal tariff rates are considered as opportunity costs. Here, given the fact of low / subsidized tariffs in low energy consuming households in both rural and urban areas, the economic potential in these customer segments become zero. Likewise, the economic potential for the other customer categories, which also have rather low tariffs, becomes zero. The total economic potential from the customers' perspective thus comes to about 2/3rds the technical potential.
- the economic potential is assessed to reduce further – to just over half of the technical potential – if the actual tariff payment is considered as a measure of opportunity cost.

[19] The retail price is significantly higher than that of the EE EM ballast, although the useful life is expected to be about the same. It may be noted however, that for the latter, there is little empirical evidence in India yet. It may also be highlighted that certain electronic ballasts manufactured / assembled in the small / tiny / cottage sector may come somewhat cheaper (in the Rs 200 to 250 per unit range) but have somewhat higher watt losses (about 3 – 3.5 watts, rather than 2 watts).

Exhibit 6.3: Electronic ballasts – Economic potential for energy savings

Sector	*Segment*	*Unit energy savings (kWh / yr)*	*Life cycle cost of saved energy (Rs / kWh)*	*Economic Potential (GWh / year) assuming*		
				LRMC as Opportunity cost	*Current Tariff as Opportunity cost*	*Actual tariff payment as Opportunity cost*
Residential	Urban High consumer	16.4	2.58	10	10	9
	Urban Low consumer	16.4	3.16	578	-	-
	Rural	16.4	3.16	409	-	-
Commercial	All	23.4	2.63	1315	1315	987
Industrial	Cottage / Small LT	41.0	1.66	498	498	374
	Other LT	41.0	1.66	299	299	224
	HT	41.0	1.55	199	199	179
Other	Public lighting	42.9	1.63	179	-	-
	Other	42.9	1.63	278	-	-
All				3766	2322	1773

6.4 Market potential

Given in Exhibit 6.4 is the market potential for energy savings from electronic ballasts.

Exhibit 6.4: Electronic ballasts – Market potential for energy savings

Sector	*Consumer awareness (%)*	*Consumer application compatibility (%)*	*Avail. due to supply / chain constraints (%)*	*Consumers with finance constraints (%)*	*Market potential (GWh / year)*		
					With all existing market constraints	*With Max relief of financial constraints*	*With relief of supply / chain constraints*
Residential							
- Urban high consumer	80	80	10	50	-	1	3
- Urban, other	70	80	10	100	-	32	-
- Rural	60	80	10	100	-	20	-
Commercial							
- All	80	80	10	50	32	84	316
Industry							
- Cottage / small LT	80	80	10	50	12	32	120
- Other LT	80	80	10	50	7	19	72
- HT	80	80	10	50	6	13	57
Other							
- Public lighting	80	80	10	100	-	11	-
- Other	80	80	10	100	-	18	-
Total					57	230	567

Electronic ballasts offer consumers several performance advantages over standard ballasts, as well as substantial energy savings. However, like the EE EM ballasts, the electronic ballasts are also expected to face significant market barriers – due largely to the fact that ballast manufacture is reserved for the small scale sector, The other market barriers for electronic ballasts may be summarized as follows:

- *Consumer awareness.* Consumer awareness is not expected to be a significant barrier any longer, particularly as evidence has increasingly gathered in recent times that electronic ballast performance is improving. Nevertheless, if most consumers are expected to be price sensitive, some mechanism may need to be developed so as to educate the consumer about benefits over the product life cycle.

- *Consumer application compatibility.* While electronic ballasts generally do not pose application difficulties, in a minority of cases the fixture may require changing as well, or at least the mounting of the new ballast may require extra work as the electronic ballasts are generally smaller than either standard or EE-EM ballasts. It is assumed that this is not a barrier in 80% of the cases.

- *Financial constraints.* The higher price of electronic ballasts is expected to present some constraint for many consumer segments, particularly in the residential sector, though also in the government sector. As a result, any proposed initiatives by the GOI to promote electronic ballasts, would need to be well targeted to the specific customer segments.

7 T5 Lamps with Electronic Ballast

7.1 Segment share of existing light points

T5 lamps have recently been introduced to the Indian market, as discussed in the Milestone 4B report. The T5 product that delivers the same lumen output as the T8 is actually a shorter tube; to compete with T12s and T8s as a replacement for existing FTLs, it is being marketed with a plastic extension on the tube. The extension houses an electronic ballast and allows the T5 to be inserted easily by the consumer in the existing FTL fixture. In parallel, T5s are also sold in the new construction market with new light fixtures designed for the T5 tube, where the ballast is located more conventionally within the fixture. These fixture-lamp packages offer additional benefits in their photometric characteristics and power efficiency.

This analysis of technical, economic, and market potential for the T5 product was prepared to approximate a comparison with other EE options, with the caveat that all the results are subject to future adjustment as T5 performance data become available. The product is so new that no performance data under Indian conditions are yet available. Also, as marketers gain experience with consumer reaction, it is quite possible that the product may be repositioned, in terms of price or other features, which may also change the results.

The analysis follows directly from that presented for T8 lamps in section 5. Assumptions toward estimating the feasible potential number of T5 light points (Exhibit 7.1) are described below:

- Essentially 0 percent of FTL light points have already been replaced with T5 lamps, due to the very recent product introduction.

- Due to the special accommodation to lamp size in positioning the T5 as a replacement product, it is expected to be targeted only at the dominant straight-tube FTL size category, and not as substitute for other sizes or lamp shapes. It is conservatively assumed that this represents 70 percent of the total FTL market.

- In the residential and industrial sectors, the share of FTL light points in the various segments is as per those for GLS lamps (refer to section 3.1 and Exhibit 3.1). In the commercial sector, no further segmentation is considered for analytical purposes.

- In the other sectors, information available from the ACEEE report published in 1991 forms the basis for the shares of the two segments considered – as no further updates are available.

Exhibit 7.1: Technically feasible number of FTL light points remaining for conversion to T5 – by customer segment

Sector	*Segment*	*%*	*Number (millions)*
Residential	Urban High consumer	1	1
	Urban Low consumer	58	31
	Rural	41	22
	All	100	53
Commercial	All	100	52
Industrial	Cottage / Small LT	50	9
	Other LT	30	6
	HT	20	4
	All	100	19
Other	Public lighting	39	3
	Other	61	5
	All	100	8
All			133

Source: NCAER (1998), ACEEE (1991)

7.2 Technical potential

The technical potential for annual energy savings is summarized in Exhibit 8.2. The detailed approach for technical potential estimation is given in the Milestone 4B report. For analytical purposes, the following input data and assumptions are used:

- there are a total of 190 million FTL points in all sectors, of which essentially none have already been converted to T5 lamps, and 70% of the remainder can be conservatively considered to be converted to T8 lamps
- one T5-with-electronic ballast (total 26 watts) is assumed to replace one standard FTL lamp (55 watts, including the standard ballast), providing a savings of 29 watts per light point
- average annual operating hours and annual utilization factor per light point vary from sector to sector, as shown in Exhibit 7.2
- after conversion to T5, there would be no significant change in annual operating hours and annual utilization factors, also shown in Exhibit 7.2

Exhibit 7.2: T5 lamps - Technical potential for energy savings

Sector / segment	*Light points (millions)*		*Utilization factor (%)*	*Operating hours / year*	*Energy savings (GWh / year)*
	Total	*Tech. Feasible conversion*			
Residential	76	53	75	1400	1,946
Commercial	75	52	60	3000	2,739
Industrial	27	19	90	3500	1,730
Others	12	8	83	4000	793
All	190	133			7,208

Source: Milestone 4B report.

7.3 Economic potential

In addition to the various assumptions highlighted in section 3 as well as those for assessing the technical potential, are the following other key assumptions:

- unit FTL price is Rs 40
- unit T5 price is Rs 600[20]
- useful economic life of FTL is about 3,000 hours
- useful economic life of the T5-with-electronic ballast product is 10,000 hours

The gain in service life, as claimed by suppliers, is a critical benefit of the T5 in the economic assessment against the standard FTL as well as T8. It needs to be field tested, and there has not been sufficient practical experience in India with these T5 products to verify whether the suppliers' claims are valid under typical Indian conditions of power quality. Without the benefit of reduced frequency of lamp replacements, the analysis would show that the economic potential drops to nearly zero and that the product's energy savings would not pay for its additional cost for most consumers under such conditions. This analysis assumes that the electronic ballast is responsible for allowing the lamps to reach the service life potential that would be expected with good power quality. Exhibit 7.3 shows the economic potential by customer segment.

Exhibit 7.3: T5 lamps – Economic potential for energy savings

Sector	*Segment*	*Unit energy savings (kWh / yr)*	*Life cycle cost of saved energy (Rs / kWh)*	*Economic Potential (GWh / year) assuming*		
				LRMC as Opportunity cost	*Current Tariff as Opportunity cost*	*Actual tariff payment as Opportunity cost*
Residential	Urban High consumer	36.5	3.14	19	-	-
	Urban Low consumer	36.5	3.67	1129	-	-
	Rural	36.5	3.67	798	-	-
Commercial	All	52.2	3.56	2739	-	-
Industrial	Cottage / Small LT	91.4	2.29	865	-	-
	Other LT	91.4	2.29	519	519	389
	HT	91.4	2.18	346	346	311
Other	Public lighting	95.7	2.33	310	-	-
	Other	95.7	2.33	483	-	-
All				7208	865	701

7.4 Market potential

The market potential for the T5 replacement product is shown in Exhibit 7.4. The T5 product is new, with very limited consumer experience, and hence the analytical conclusions are conjectural. The assumptions are

[20] The current (2001) price for this product may be as high as Rs 750, with discounts for quantity purchased as well as negotiable terms for installment payments. The indicated price assumes that the price may fall once the product gains market share and production levels increase from the current introductory period.

consistent with those made for competitively positioned products, and are described below:

- *Customer awareness*: Customer awareness barriers are assumed to have the same impact as for the T8 lamps. Ultimately this may be unduly conservative, because the T5 is more easily differentiated from standard FTLs than the T8, because the T5 is noticeably thinner (less than half the diameter of the standard FTL) and has multiple and substantial feature differences compared to the T8: greater energy savings, longer life, reduced lumen depreciation, higher power factor, reduced flicker, higher price. In all, the T5 is easily positioned as a high quality product.

- *Customer application compatibility*: The plastic tube extension is the T5's modification to accommodate fixture compatibility for consumers. A correction factor has been applied previously (see technical potential, section 7.2) to account for FTL fixtures where T5s will not fit. The customer application compatibility barrier is set at 90 percent, the same factor as for T8s, to account for specialty applications where T5s may not be available in certain color ranges, for example, although generally T5 color rendition is far superior to that of standard FTLs.

- *Supply chain constraints*: Although supply chain constraints would initially pose considerable barriers, in the long run they are assumed to be no more severe than for T8 lamps, if consumer demand were evident. Considering that FTL products are branded, suppliers are not expected to put up long-term resistance to providing the higher value T5 product as a substitute for standard lamps once consumers exhibit convincing interest, particularly as it provides the leading suppliers with an opportunity to increase market share of their ballasts.

- *Financial constraints*: The principal barrier to T5 penetration appears to be its high price. The lifecycle cost of energy savings for this product is greater than its value at current tariff levels for most consumer categories. On this basis, the product is not financially attractive unless financial incentives are offered, with the exception of customers who attach additional value to the product's quality, aesthetic appeal, or other features.

Exhibit 7.4: T5 lamps – Market potential for energy savings

Sector	*Consumer awareness (%)*	*Consumer application compatibility (%)*	*Avail. due to supply / chain constraints (%)*	*Consumers with finance constraints (%)*	*Market potential (GWh / year)*		
					With all existing market constraints	*With Max relief of financial constraints*	*With relief of supply / chain constraints*
Residential							
-Urban high consumer	80	90	90	50	-	13	-
- Urban, other	70	90	90	100	-	640	-
- Rural	60	90	60	100	-	259	-
Commercial							
- All	80	90	90	50	-	1775	-
Industry							
- Cottage / small LT	80	90	80	50	-	498	-
- Other LT	80	90	90	50	126	336	140
- HT	80	90	90	50	101	224	112
Other							
- Public lighting	80	90	90	100	-	201	-
- Other	80	90	90	100	-	313	-
Total					227	4258	252

In summary, T5 lamps offer many attractive product benefits including high energy savings, but at a cost that exceeds the value of energy savings for most consumers, according to the assumptions of this analysis. Sustained financial incentives would be required to penetrate most consumer markets, until tariff levels rise toward the long run marginal cost of electricity.

8 EE Refrigerators

8.1 Segment share of existing refrigerators

EE refrigerators are considered for replacement of existing refrigerators – provided the replacement is technically feasible. For analytical purposes, all refrigerators are considered to be in the residential and commercial sectors only. The Milestone 4B report gives the details of the basis and assumptions used to estimate the total number of refrigerators in these two customer categories. This is further split between the various customer segments as shown in Exhibit 8.1 on the following basis:

- *Rural residential sector*: As per a survey conducted by the NCAER, about 24% of the total refrigerator sales to residential consumers were to rural households. In the absence of any recent information regarding the sales pattern of refrigerators, it is assumed for analytical purposes that about 24% of refrigerators are in the rural households.

- *Urban residential sector*: Households in urban areas have the remaining 76% of refrigerators – including 3% in the high consumption category and 73% in the other urban households. Although there are only about 1-2% high consumption category households as defined for analytical purposes (> 300 kWh / month consumption), it is expected that these households comprise the bulk of the households that have more than one refrigerator.[21]

- *Commercial sector*: No further segmentation is considered for analytical purposes.

Exhibit 8.1: Technically feasible no. of refrigerators for replacement by EE refrigerators

Sector	*Segment*	*%*	*Number (millions)*
Residential	Urban high consumer	3	0.6
	Urban other	73	14.9
	Rural	24	4.9
	All	100	20.4
Commercial	All	100	1.1
Total			**21.5**

Source: Refer to Milestone 4B report.

[21] As per a survey conducted by MODE in 1997/98, about 3% of the 23% households that had refrigerators, had more than one refrigerator.

8.2 Technical potential

The technical potential for energy savings is summarized in Exhibit 8.2, and along with inputs / assumptions / consistency checks, is detailed in the Milestone 4B report. For analytical purposes, the following input data and assumptions are used:

- *The total stock of refrigerators in use is about 23.9 million, of which about 5% has* already been replaced by EE refrigerators, and 90% can be possibly converted to EE refrigerators (i.e. about 21.5 million)
- The refrigerators (whether existing ones, or the replaced EE ones) are in use throughout the year
- The average energy consumption of refrigerators for residential use is about 1.7 kWh / day, and in commercial use is about 1.9 kWh / day.[22]
- Among the best available EE refrigerators may be considered for replacement – with energy consumption of 0.5 kWh / day for the residential sector, and 0.7 kWh / day for the commercial sector.[23]
- After conversion to EE refrigerators, there would be no significant change in the refrigerator usage pattern.

Exhibit 8.2: EE Refrigerators - Technical potential for energy savings

Sector	*Numbers (millions)*		*Energy savings (GWh / year)*
	Total	*Tech. feasible conversion*	
Residential	22.7	20.5	8,608
Commercial	1.2	1.1	470
Total	23.9	21.5	9,077

In line with the stock data, the bulk of the technical potential is in the residential sector.

8.3 Economic potential

In addition to the assumptions listed in sections 3, 8.1 and 8.2, the following assumptions are used to estimate the economic potential of energy savings from use of EE refrigerators:

[22] This assumption is consistent with sources cited in the 1996 EMCAT study and with studies performed in 1999 for refrigerator EE labeling. See the Milestone 4B report. A typical refrigerator in a commercial establishment is assumed to be somewhat larger than that in the residential sector.

[23] *This would be in line with the type of refrigerators available in South Korea or Thailand, where* the consumption of 185 litre capacity refrigerators is about 200 kWh / year, and of 230 litre refrigerators is about 250 kWh / year. At present, the best available refrigerators in India have a consumption of about 0.8 kWh / day.

- The average cost of a refrigerator used by residential customers is about Rs 9,000; an EE refrigerator would cost about 15% more.[24]

- The average cost of a refrigerator used in commercial establishments is about Rs 10,000, and a corresponding EE refrigerator would cost about 15% more.[25]

- the useful economic life of all standard and EE refrigerators of all sizes is about 15 years

The results are presented in Exhibit 8.3. Given that the life cycle cost of saved energy comes to be much less than the LRMC or even tariff levels, the economic potential equals the technical potential. However, if the fact that not all consumer pay for the power they consume is taken in to account, the economic potential is estimated to fall by about 25%.

Exhibit 8.3: EE Refrigerators – Economic potential for energy savings

Sector	*Segment*	*Unit energy savings (kWh / yr)*	*Life cycle cost of saved energy (Rs / kWh)*	*Economic Potential (GWh / year) assuming*		
				LRMC as Opportunity cost	*Current Tariff as Opportunity cost*	*Actual tariff payment as Opportunity cost*
Residential	Urban High consumer	421	0.55	258	258	232
	Urban other	421	0.69	6,284	6284	5027
	Rural	421	0.69	2,066	2066	1240
Commercial	All	436	0.59	470	470	352
All				9,077	9,077	6,851

8.4 Market potential

EE refrigerators have high economic as well as technical potential. However, market barriers are very significant and reduce market potential to less than 3% of the technical potential. The market barriers are as follows:

- *Consumer awareness*: Not expected to be a significant barrier provided an aggressive promotion campaign is launched

- *Consumer application compatibility*: Not expected to present a market barrier. In general, once manufacturers offer EE models and a market is established, they offer the same features as the standard efficiency models

- *Supply chain constraints*: Supply chain constraints are expected to be considerable. While EE refrigerators do not present technical challenges, they require many changes in manufacturer's production line, and require the use of more costly

[24] Based on prices in 2000 for refrigerators of various sizes and makes as presented in the EMCAT report, escalated at 8% per year (the general inflation rate).

[25] Based on prices in 2000 for refrigerators of various sizes and makes.

materials. To the extent the manufacturers are regionally oriented, relatively small scale, they will resist such changes. Furthermore, in view of the price conscious Indian consumer, manufacturers and distributors are likely to believe that a low cost (thereby standard) model be available to appeal to the relatively low income user.

- *Financial constraints*: The high price of EE models and their cost premium is expected to be the largest deterrent to market penetration. Suitable intervention through well-structured programs is likely to reduce the impact of the financial constraints – particularly those seen by the low / middle income residential consumers in urban and rural areas.

It is clear that although overcoming the supply-chain constraints may make significant gains, they are nowhere close to the benefits that would be gained through a structured programmatic intervention that aims to overcome financial barriers.

Exhibit 8.4: EE Refrigerators– Market potential for energy savings

Sector	*Consumer awareness (%)*	*Consumer application compatibility (%)*	*Avail. Due to supply / chain constraints (%)*	*Consumers with finance constraints (%)*	*Market potential (GWh / year)*		
					With all existing market constraints	*With Max relief of financial constraints*	*With relief of supply / chain constraints*
Residential							
- Urban high consumer	80	100	60	50	56	124	93
- Urban, other	70	100	60	100	-	2639	-
- Rural	60	100	60	100	-	744	-
Commercial							
- All	80	100	60	50	85	225	141
Total					140	3732	234

9 EE Room Air-conditioners

9.1 Segment share of existing air-conditioners

EE room air-conditioners are considered to replace the standard air-conditioners. In line with the definition of urban high consumer category (as adopted for analytical purposes), no other residential category would have a significant use of air-conditioners. The only other customer category that has a significant use of room air-conditioners is the commercial sector. Although the total number of air-conditioners in use is estimated at some 1.63 million (see Milestone 4B report for further details), it is assumed that it is technically possible to replace about 90% of them by EE models. Exhibit 9.1 gives population of room air-conditioners that can possibly be replaced by EE models.

Exhibit 9.1: Technically feasible no. of Room Air-conditioners for replacement by EE Air-conditioners

Sector	*Segment*	*%*	*Number (millions)*
Residential	Urban high consumer	50	.7
Commercial	All	50	.7
Total			**1.5**

Source: Refer to Milestone 4B report.

9.2 Technical potential

The technical potential for annual energy savings is summarized in Exhibit 9.2, and along with assumptions / inputs / consistency checks etc., is detailed in the Milestone 4B report. For analytical purposes, the following input data and assumptions are used:

- the typical / average rating of a standard air-conditioner is 2500 watts
- the typical / average rating of an EE air-conditioner is 1861 watts[26] (thereby leading to a savings of about 639 watts)
- the effective full-load operation of an air-conditioner in the residential sector 1600 hours, and in the commercial sector about 2000 hours
- these utilization levels would remain unchanged if EE models were to be deployed

Exhibit 9.2: EE Air-conditioners - Technical potential for energy savings

Sector	*Numbers (millions)*		*Energy savings (GWh / year)*
	Total	*Tech. Feasible conversion*	
Residential	0.8	0.7	750
Commercial	0.8	0.73	937
Total	**1.6**	**1.5**	**1687**

Source: Milestone 4B report

26 Assuming a coefficient of performance (COP) of 9.0.

9.3 Economic potential

In addition to the various assumptions highlighted in section 2, 9.1 and 9.2, the following are the other key inputs for the estimation of economic potential:

- the price of a standard, 1.5-ton air-conditioner is about Rs 25,000[27]
- the EE air-conditioners fetch a price premium of 20%
- the useful life of both standard and EE units is about 10 years.

The life cycle cost of saved energy (from replacement of standard by EE air-conditioners) comes to be much below the LRMC as well as the nominal tariff levels – and the economic potential is thus estimated to be the same as the technical potential (see Exhibit 9.3). However, given the fact that certain consumers may not be paying to the utilities for the power they consume, the economic potential reduces (by about one-fifth) when the opportunity cost is considered to be the actual tariff payment.

Exhibit 9.3: EE Air-conditioners – Economic potential for energy savings

Sector	*Segment*	*Unit energy savings (kWh / yr)*	*Life cycle cost of saved energy (Rs / kWh)*	*Economic Potential (GWh / year) assuming*		
				LRMC as Opportunity cost	*Current Tariff as Opportunity cost*	*Actual tariff payment as Opportunity cost*
Residential	Urban High consumer	1022	0.98	750	750	675
Commercial	All	1278	0.78	937	937	703
All				**1,687**	**1,687**	**1,378**

9.4 Market potential

Given the fact that the air-conditioner is an item that is normally used by the high income levels and the upper strata of Indian society, the technical and economic potential for energy savings from EE refrigerators are suitably lower than for many other products. And the market potential is estimated to be even lower.

However, it is important to recognize that consumer awareness is not expected to be a major constraint (in general, the target customer categories would be more willing and able to understand the benefits of EE technologies). And neither is consumer application compatibility nor supply chain issue likely to pose any constraints at all. Given this, it is expected that finance constraints (that impede expenditure of the incremental amount of some 20%) may be most severe. The market potential estimates are presented in Exhibit 9.4.

[27] Based upon a survey of models available in January 2001.

Exhibit 9.4: EE Air-conditioners – Market potential for energy savings

Sector	*Consumer awareness (%)*	*Consumer application compatibility (%)*	*Avail. Due to supply / chain constraints (%)*	*Consumers with finance constraints (%)*	*Market potential (GWh / year)*		
					With all existing market constraints	*With Max relief of financial constraints*	*With relief of supply / chain constraints*
Residential - Urban high consumer	80	100	100	50	270	600	270
Commercial - All	80	100	100	50	562	750	562
Total					**832**	**1,350**	**832**

10 Energy Efficient Ceiling Fans

10.1 Segment share

Energy efficient ceiling fans were submitted as a recommendation in the 1991 ACEEE report, noting the pervasive use of this consumer product in households as well as commercial establishments. In 2000, they are still evidently not available in the Indian market, yet the potential remains and grows with the growth of the population of households and businesses. This analysis provides an update to the ACEEE analysis, based upon the same assumptions of technical EE potential available through the substitution of the existing fan motor with an EE motor. Hence, the analysis for this product may be considered as a subset of the portion of the analysis in section 12 with respect to the potential for EE motors, in the single phase, fractional horsepower size category. Exhibit 10.1 shows the total number of conversion sites that are estimated to be technically possible.

Exhibit 10.1: Technically feasible no. of EE ceiling fans, by customer segment

Sector	*Segment*	*%*	*Number (millions)*
Residential	Urban High consumer	2	3
	Urban Low consumer	56	74
	Rural	42	56
	All	100	133
Commercial	All	100	7
Industrial	Cottage / Small LT	50	3
	Other LT	30	2
	HT	20	1
	All	100	7
Other	Institutional	100	9
All			156

Source: ACEEE (1991) and Milestone 4B report.

10.2 Technical potential

Details regarding the various assumptions and inputs for technical potential estimation are presented in the Milestone 4B report. The various assumptions may be summarized as follows:

- the assumed potential energy savings is 15 percent, based upon an available range of 10-20 percent. [28] For the assumed rating of the typical ceiling fan, 70 watts, the available energy savings are approximately 11 watts.

- Ceiling fans are assumed on average to be used 2,500 hours per year in households, based upon ACEEE.[29] This usage was not changed for other segments, there being no supporting data, and considering that the non-residential segments represent a relatively small share of the appliance stock.

[28] ACEEE, p.70-17.
[29] ACEEE, p200.

- Utilization is assumed to be 100 percent. Although many fans have adjustable speed settings, this is generally accomplished by resistance type regulator, which does not reduce the net power requirement when reducing the speed.

- All existing and new existing ceiling applications are assumed to be technically feasible for substitution with EE models.

The technical potential for savings thus projected is shown in Exhibit 10.2.

Exhibit 10.2: EE ceiling fans - Technical potential for energy savings

Sector / segment	*Total Sites*	*Tech. Feasible conversions*	*Utilization factor (%)*	*Operating hours / year*	*Energy savings (GWh / year)*
Residential	133	133	100	2500	3,488
Commercial	7	7	100	2500	179
Industrial	7	7	100	2500	179
Others	9	9	100	2500	243
All	156	156			4,089

Source: Milestone 4B report

10.3 Economic potential

Additional key assumptions used for the economic analysis include:

- The incremental cost of the EE unit, compared to existing fans, was assumed to be Rs 200, consistent with the ACEEE report and allowing for escalation.

- The EE model is assumed not to have improvements in service life or other features, compared to the standard unit, relevant to the economic evaluation.

On the basis of these assumptions, the life-cycle cost of saved energy was found to be significantly below the LRMC of electricity in all classes, but still greater than the price of electricity in the largest ceiling fan markets: low to middle income households in both urban and rural areas. Hence the sharp reduction in economic potential when considered from the consumer's perspective. The results are presented in Exhibit 10.3.

Exhibit 10.3: EE ceiling fans – Economic potential for energy savings

Sector	*Segment*	*Unit energy savings (kWh / yr)*	*Life cycle cost of saved energy (Rs / kWh)*	*Economic Potential (GWh / year) assuming*		
				LRMC as Opportunity cost	*Current Tariff as Opportunity cost*	*Actual tariff payment as Opportunity cost*
Residential	Urban High consumer	26	1.22	70	70	63
	Urban Low consumer	26	1.56	1,951	0	0
	Rural	26	1.56	1,467	0	0
Commercial	All	26	1.22	179	179	134
Industrial	Cottage / Small LT	26	1.22	90	90	67
	Other LT	26	1.22	54	54	40
	HT	26	1.02	36	36	32
Other	Institutional	26	1.22	243	243	121
All				4,089	671	458

10.4 Market potential

Exhibit 10.4 reports the market potential for energy savings from energy efficient ceiling fans.

Exhibit 10.4: Electronic ballasts – Market potential for energy savings

Sector	*Consumer awareness (%)*	*Consumer application compatibility (%)*	*Avail. due to supply / chain constraints (%)*	*Consumers with finance constraints (%)*	*Market potential (GWh / year)*		
					With all existing market constraints	*With Max relief of financial constraints*	*With relief of supply / chain constraints*
Residential							
- Urban high consumer	80	100	30	50	15	17	50
- Urban, other	70	100	30	100	-	410	-
- Rural	60	100	30	100	-	264	-
Commercial							
- All	80	100	30	50	32	43	108
Industry							
- Cottage / small LT	80	100	30	50	8	22	27
- Other LT	80	100	30	50	10	13	32
- HT	80	100	30	50	8	9	26
Other							
- Institutional	80	100	30	100	-	58	-
Total					73	835	243

EE ceiling fans may be expected to face significant market barriers, and this is perhaps evident in the fact that they do not exist in the market today. The greatest apparent barrier is the financial constraint, in that the majority of consumers

currently pay such low tariffs that the expected price premium of EE ceiling fans would not be recovered by the energy savings. However, there are important other barriers that would affect market penetration even if the financial barriers were addressed through incentives. The barriers are summarized as follows:

- *Consumer awareness.* Consumers are being introduced to concepts of energy efficiency benefits through efficient lighting products, but are certainly unaware now of EE ceiling fans, these being unavailable in any case. The analysis assumes that consumer awareness barriers could be overcome through effective marketing, and that this does not ultimately represent a major barrier. awareness is not expected to be a significant barrier any longer, particularly as

- *Consumer application compatibility.* Although no application compatibility barrier is assumed, this could come into play if EE fans are not offered with other optional features desired by consumers.

- *Supply chain constraints.* The major barriers are three-fold. First, the fractional horsepower EE motors required for this product are not manufactured in India, although technical capability exists among manufacturers. Second, the use of EE motors in the product would be the responsibility of original equipment manufacturers (OEM) whose priority is to minimize the cost of components, because they operate in a commodity-type market that is primarily driven by price. This issue is discussed further in section 12 and in the Milestone 4B report's discussion of EE motors. The OEM market has typically been the most difficult to influence in terms of their use of EE motors. Third, a significant portion of ceiling fans are manufactured by the small scale sector, which may be expected to resist change to higher cost, high quality products.

- *Financial constraints.* As noted, although the cost premium of EE ceiling fans could be relatively low, the energy savings still do not pay for the premium for in the largest consumer markets. From the national perspective, considering the cost of providing electricity, EE ceiling fans are quite cost effective, and financial incentives would be worthwhile.

11 EE Motors

11.1 Sectoral Share

The total capacity of motors in use in India is estimated at about 71,600 MW, which comprises:

- 27,200 MW of single-phase motors
- 32,200 MW of three-phase squirrel gauge induction motors
- 12,200 MW of other three-phase motors.

Exhibit 11.1 shows the stock of single-phase and three-phase induction motors by capacity and customer segment. The basis for this distribution of the various capacity ranges by customer segment is detailed in the Milestone 4B report.

Exhibit 11.1: Installed motor capacity (MW)

	Stock of motors in use, by kW size range						
Sector	*<7.5**	*<7.5*	*9.3-15*	*18.5 - 30*	*37 - 45*	*>45*	*All*
Residential - Urban high consumers	2,072	-	-	-	-	-	2,072
- Urban low consumers	8,289	-	-	-	-	-	8,289
- Rural	7,200	-	-	-	-	-	7,200
- All	17,561	-	-	-	-	-	17,561
Commercial	3,808	2,193	998	-	-	-	7000
Industrial - Cottage / small LT	4,953	4,279	-	-	-	-	9,232
- Other LT	-	829	5,820	2,575	1,481	-	10,705
- HT	-	415	2,910	1,288	740	7,115	12,468
- All	4,953	5,523	8,729	3,863	2,221	7,115	32,405
Other	890	513	233	-	-	815	2,452
Total	27,212	8,229	9,961	3,863	2,221	7,930	59,417

**: Single-phase motors; all other are three-phase squirrel gauge induction motors.*

11.2 Technical potential

For analytical purposes, it is assumed that only EE motors of Indian make would be deployed in significant numbers. Although such motors are more efficient than standard motors, they are somewhat less efficient than some leading brands manufactured internationally.[30] Nevertheless, the efficiency improvements are significant, on the basis of which the technical potential for energy savings is assessed. The energy savings results are summarized in Exhibit 11.2.

The key assumptions for technical potential estimation include (among other) the following:

[30] Indian motors are less efficient than those manufactured in several other countries by several percentage points, attributed primarily to lack of local availability of some of the specialty steels required in the more efficient models.

- Although several Indian manufacturers offer EE motors in their product line, even in recent times, less than 1% of motors sold can be considered as being EE. Overall, the share of EE motors in use may be reasonably considered to be negligible.

- For technical / engineering / operational reasons, it may not be possible to replace 20% of the motors by EE motors

- The average efficiency levels of the EE motors is higher than that of the existing stock of motors as follows: 10% for <7.5 kW motor (single phase), 3% for <7.5 kW motor (three-phase), 2% for 9.3 to 15 kW motors, 2% for 18.5 to 30 kW motors, 1% for 37 to 45 kW motors, and 1% for >45 kW motors.

- For analytical purposes, the annual operating hours are assumed to be 2500 hours for residential applications, 3000 hours in the commercial sector, 3000 hours in all LT industrial, 6000 hours in HT industry and 4000 hours in other sectors.

- Suitable assumptions regarding load factor, utilization / duty factor, load factor efficiency loss, EE unit efficiency improvement are also made (the basis is discussed in the Milestone 4B report).

- EE motors are introduced to the extent that existing motors reach the limits of their useful economic life, and are thus replaced by EE motors.

Exhibit 11.2: Technical potential for energy savings (GWh / year)

	By motor size range (in kW) in use						
Sector	*<7.5**	*<7.5*	*9.3-15*	*18.5 - 30*	*37 - 45*	*>45*	*All*
Residential - Urban high consumers	42	-	-	-	-	-	42
- Urban low consumers	2415	-	-	-	-	-	2415
- Rural	1707	-	-	-	-	-	1707
- All	4164	-	-	-	-	-	4164
Commercial	929	127	35	-	-	-	1091
Industrial - Cottage / small LT	927	183	-	-	-	-	1110
- Other LT	-	36	150	64	18	-	267
- HT	-	38	159	68	19	178	461
- All	927	257	309	132	37	178	1839
Other	235	31	8	-	-	14	288
Total	6255	414	353	132	37	191	7382

**: Single-phase motors; all other are three-phase.*

11.3 Economic potential

In addition to the various assumptions outlined in sections 3, 11.1 and 11.2, the following other assumptions / key inputs are made towards estimating the economic potential:

- For analytical purposes, typical unit sizes are assumed in each size range category. The typical sizes are assumed to range from 0.1 kW (single phase motors used in residential sector) to 55 kW (three-phase motors in the highest size range of >45 kW).

- For each typical size, a typical standard motor price is assumed. For instance, the price of a new single-phase 0.1 kW motor is assumed to be Rs 1000 that of the 55 kW three-phase motor is taken as over Rs 151,800.[31] For EE motors of the same typical sizes, the motor price is assumed to be 15% higher than that of the standard motor.[32]

- The useful economic life of a standard single-phase motor (<7.5 kW size) is assumed to 25,000 hours, and for all standard three-phase motors (irrespective of size) as 40,000 hours. For analytical, the same useful life is assumed for all EE motors as well

- The single-phase motors – both standard and EE – are expected to last for about 25,000 hours without any rewinding

- Rewinding of three-phase motors however, would be required repeatedly during their useful economic life. For standard three-phase motors, the first rewinding is required after 6,000 hours of operation, and each subsequent rewinding once a year.[33] For the EE motors, the first rewinding is after 12,000 hours of operation, and each subsequent rewinding once a year.

- Upon each successive rewinding, the average efficiency of the standard motor is assumed to reduce by 0.5%. A similar level of reduction is assumed for the EE motors

- The cost of rewinding for a standard or EE motor of any size, is assumed as 5% of the price (capital cost) of the standard motor of that size.

The economic potential so estimated is shown in Exhibit 11.3.

---

31 As per information available in the EMCAT report. Updated to 1999/2000 level by using the general inflation rate of 8% per annum.

32 Price differential as per EMCAT. Also supported by various manufacturers.

33 It is understood that the normal practice is for industrial enterprises to send a motor for rewinding (whether or not it is burnt out) at the time of annual maintenance.

Exhibit 11.3: EE motors - Economic potential for energy savings (GWh / year)

Sector	*Economic potential (GWh / year) assuming*		
	LRMC as opportunity cost	*Current tariff as opportunity cost*	*Actual tariff as opportunity cost*
Residential - Urban high consumers	42	42	37
- Urban low consumers	2415	-	-
- Rural	1707	-	-
- All	4164	42	37
Commercial	1091	1091	818
Industrial - Cottage / small LT	1110	1110	833
- Other LT	267	267	201
- HT	461	264	238
- All	1839	1642	1271
Other	288	275	137
Total	7382	3049	2264

The economic potential for energy savings is expected / projected to:

- equal the technical potential, from the overall national perspective, as the life cycle cost of saved energy comes out significantly lower than the LRMC for all customer segments

- reduce to less than half the technical potential from the end-user perspective – the implicit assumption being that a rational consumer would compare the life cycle cost of saved energy to the tariff rates he pays

- reduce further to about 30% of the technical potential, in recognition of the fact that several consumers in all segments in fact may not be paying for the power they consume, and thus would find little reason (if any) to invest in a marginally expensive EE motor

11.4 Market potential

The assumptions concerning market barriers are as follows:

- *Consumer awareness.* Consumer awareness is evaluated as an important and persistent barrier in most segments that use three-phase motors. A possible exception may be the mid- and large sized industrial establishments. In general, many industrial users also view motors as commodities and require considerable market conditioning and intervention efforts to modify their purchasing behavior. The facts that consumers are largely unsophisticated (and hence rely on the advice of distributors) while being price conscious would be important considerations in designing a market conditioning and intervention program.

- *Consumer application compatibility.* Application compatibility is generally not a market barrier once the demand has increased to the point that manufacturers supply complete lines of EE models (which is a supply chain issue). In this analysis, technical compatibility of EE motors (such as compatible frame configurations) is considered not to be any barrier at all.

- *Supply chain constraints.* The significant drop in savings potential between the economic level and market level is primarily due to the barrier to improving energy efficiency in fractional horsepower motors, which are estimated to have a significant market share in India. Energy efficiency potential tends to be quite high for this size category, but it is very difficult to affect this market because the dominant motor purchasers are original equipment manufacturers (OEMs) rather than direct consumers. OEMs have no incentive to demand higher efficiency motors, as they are working in a highly price competitive market. In the US, legislated motor standards under EPACT exempted fractional motors from efficiency standards. For larger motors, supply chain constraints are assumed to be low once current stock shortages are resolved, as EE motors are now reportedly available from manufacturers but not effectively available from distributors. This condition is assessed as a "chicken and egg" situation in which suppliers are limiting production until they perceive sufficient demand, while consumers are not able to express growing demand when the supply is not available, and under their typical purchasing practices they cannot wait a long time for orders to be filled. Promotion and market conditioning are expected to resolve this barrier.

- *Financial constraints.* The financial constraints are in line with those for other EE technologies.

Exhibit 11.4: EE Motors – Market potential for energy savings

Sector	*Segment*	*Consumer awareness (%)*	*Consumer application compatibility (%)*	*Avail. due to supply / chain constraints (%)*	*Consumers with finance constraints (%)*	*Market potential (GWh/ year)*		
						Without financial incentives	*With financial incentives*	*Without supply chain constrain.*
Residential	Urban High cons.	100	100	80	50	-	-	19
	Urban Low cons.	100	100	80	100	-	-	-
	Rural	100	100	80	100	-	-	-
Commercial	All	100	100	80	50	-	39	348
Industry	Cottage /small LT	100	100	80	50	17	44	368
	Other LT	100	100	80	50	40	107	50
	HT	100	100	80	50	76	295	95
Other	All	100	100	80	100	-	21	-
Total						**133**	**506**	**881**

The results show that programmatic interventions to remove both financial barriers as well as supply-chain barriers would be useful for increasing the market penetration of EE motors.

11.5 Replacement of motors that need rewinding

The analysis in sections 11.3 and 11.4 is based on the assumption that the existing stock of motors would be replaced only when they come to the end of their useful life. Under these conditions, when EE motors are substitutes only for standard, new motors, the price premium is in the range of 10 percent to 15 percent, and the cost of saved energy is very low compared to industrial tariffs. In this case, financial constraints are relatively low, after awareness building, for most consumer segments.

However, if instead of rewinding, the standard motor were to be replaced by an EE motor, the price premium is very large – a factor of 10 to 20. Nevertheless, the technical, economic and market potentials would be considerably higher as shown in Exhibit 11.5.

Exhibit 11.5: EE motors - Energy savings potential (GWh / year)

	EE motor replacement at end of useful life of Standard motor	*EE motor replacement at time of rewinding of standard motor*
Technical potential	7382	13241
Economic potential		
- national perspective	7382	5519
- consumer perspective	2264	731
Market potential		
- Market constrained	133	106
- Max relief of financial constraints	506	2610
- Relief of supply-chain constraints	881	137

Annexure

Annex 3.1: Long run marginal cost estimation

Long run marginal cost estimation for a power utility calls for a cost of service (COS) analysis. The COS methodology is discussed below, followed by an overview of the existing status of data in Indian power utilities.

A3.1.1 Cost of service (COS) analysis

The total costs incurred in the generation, transmission and distribution of electricity is to be allocated to each customer category, which forms a basis for understanding the existing cross-subsidy structure. The two key elements of this COS analysis are:

- on arriving at a suitable method of costing
- on deciding how these costs should be allocated to the different customer categories

Exhibit A3.1.1 shows the two generally accepted approaches to costing: embedded costs and marginal costs. It is evident that in order to gain a reasonably quick appreciation of revenue to cost relationships among various customer categories, a COS study should be conducted on the basis of embedded costs. It is important to note however, that in both cases, costs include all:

- operating and maintenance expenses (including fuel)
- depreciation expenses, and
- return on capital (including both debt interest payments as well as equity, if any).

Exhibit A3.1.1: Approaches to costing

Embedded cost approach	• Uses historical accounting costs. • Its greatest advantage is that it relies on data that are usually readily available – as for most part, statistical and financial data that are fundamental to the power utility's normal reporting requirements are used.
Marginal cost based approach	• Estimates the resource costs of the utility in generating and supplying an additional (kWh). • Data requirements for marginal costing analyses are very extensive, and considerable time and effort would be usually required to first assemble the data.
Major differences	• Relates to the differences in their underlying concepts of cost • The relative merits of using either approach may be debated -- ease of data availability and urgency for obtaining results are usually the critical factors. • It may be envisaged however, that the embedded cost approach gives the desired levels of cost-based tariffs, and that incremental tariffs be based on the marginal cost approach.

Cost Allocation

Exhibit A3.1.2 explains the two broad approaches used for allocating costs between various services and customer categories. The database for both approaches is the same, except that realistic estimates of non-technical losses are required where normalized sales figures are used. Owing to poor energy accounting practices however, it is not possible to reasonably estimate the non-technical losses by customer category.

Exhibit A3.1.2: Approaches for cost allocation

- Where normalized sales figures are used, and which include revenues that would have resulted had non-technical (commercial) losses not occurred. The tariff rates applicable during the concerned period are used along with "normalized" sales to arrive at "normalized" revenues. The resulting "normalized" revenues provide a clear indication of average tariff levels without being distorted by the revenue and cost effects of a significant level of non-technical losses. Note: It is important however, that realistic estimates of non-technical losses be available for various customer categories.
- Where the actual recorded billable sales are used to arrive at revenues, along with applicable tariff rates during the concerned period.

A3.1.2 Data inadequacies

By way of an example of data inadequacies for LRMC estimation, the problems encountered in asset registers (as in one particular utility) are detailed below. In the LRMC calculations, a good database on fixed assets is essential – not only for purposes of cost allocation between generation / transmission / distribution / but also for allocation between customer categories, allocations between various voltage levels etc.

The accounting norms followed by Indian power utilities in respect of Fixed Assets are governed by the Uniform Commercial Accounting system, prescribed by the Government of India through the Electricity (Supply) Annual Account Rules 1985. All accounts are maintained as per the prescribed Chart of Accounts. Although these Guidelines have stipulated the maintenance of Fixed Asset Registers and Capital Works-in-Progress (CWIP) registers, and procedures to ensure their correctness, the prescribed practices are not actually followed.

The fixed assets shown in the utility's Balance Sheet are therefore only indicative, for (among others) the following reasons:

- Some of the Account Rendering Units (ARU's) do not maintain fixed asset registers – while many others do not update them regularly (in fact, some have not updated them for several years).
- In some cases, the Asset register does not reflect additions during the year, or assets are capitalized only a year (or more) after commissioning. Thus, depreciation is wrongly provided for, to that extent.
- Loss of assets due to theft is not quantified and deducted from Fixed Assets
- Assets transferred from one circle to another are not properly accounted for. This is specially true of assets, which are to be transferred from the project circles to the respective Generation circles, on commissioning.
- Loss of assets due to floods, fire and other natural calamities are not systematically quantified and deducted
- CWIP registers are sometimes capitalized before a work order is closed – while in other cases may not be capitalized even after closure and commissioning. This problem may be attributed to the loss in transit of the completion certificate from the field to the circle office.

- The Book value of assets does not indicate the true depreciated value of the assets, as some 'Fast moving items' are recorded at Standard Cost and not Actual cost
- There is no procedure to systematically detect and dispose off idle assets.
- Fixed Asset registers are supposed to be verified at least once a year by the field engineers. The authenticity of this verification certificate is debatable.
- There is no recorded information on the physical condition of the asset as no technical evaluations are carried out (even by the field engineers). Therefore, the Asset Registers do not reflect the effective remaining life of the asset (a function of usage, maintenance etc.) – even though the total life of the asset is based on CEA norms

Annex 3.2: Nominal tariff rates

Exhibit A3.2.1: Nominal tariff rates in Tamil Nadu

Tariff category		*With effect from*		
		7Jan 2000	*19 Jul 1998*	*% increase*
HT - I	Chennai Metropolitan			
	- p / kWh	350	330	6.1%
	- Rs / kVA / month	150	150	-
	Non-metropolitan			
	- p / kWh	340	320	6.3%
	- Rs / kVA / month	150	150	-
HT - II	Chennai Metropolitan			
	- p / kWh	290	255	13.7%
	- Rs / kVA / month	125	110	13.6%
	Non-metropolitan			
	- p / kWh	280	245	14.3%
	- Rs / kVA / month	125	110	13.6%
HT - III	Chennai Metropolitan			
	- p / kWh	390	345	13.0%
	- Rs / kVA / month	200	170	17.6%
	Non-metropolitan			
	- p / kWh	380	335	13.4%
	- Rs / kVA / month	200	170	17.6%
HT - IV	LI Societies (Agri)			
	- p / kWh	25	25	-
HT-V	Supply to Pondicherry			
	Wheeling charge			
	- p / kWh	10	10	-
	- % loss	4	4	-
LT - IA	Fixed charge			
	Domestic light and fan			
	- current transformer service (Rs / kW / month)	1	1	-
	Other services			
	- upto 50 kWh / month	nil	nil	-
	- others (Rs per service per month)	5	5	-
	Energy charge (paise / kWh)			
	- upto 25 kWh / month	65	65	-
	- 26 to 50 kWh / month	75	75	-
	- upto 25 kWh / month	75	65	15.4%
	- 26 to 50 kWh / month	85	75	13.3%
	- 51 to 100 kWh / month	150	130	15.4%
	- 101 to 300 kWh / month	220	195	12.8%
	- over 301 kWh / month	305	275	10.9%
	Minimum monthly charge (Rs / service)	10	10	-
	Huts (one 40 watts light bulb)	nil	nil	-
LT - IB	Now integrated with LT - IA			
LT - IIA	Public lighting and Public water supply (paise / kWh)			
	- in village panchayats, town panchayats & township areas	160	160	-
	- Municipalities and municipal corporation areas	175	175	-

	Minimum monthly charges (Rs / service)	20	20	-
LT - IIB	Educational inst, etc.			
	Fixed charge			
	- current transformer service (Rs / kW / month)	1	1	-
	- other services (Rs per service per month)	10	10	-
	Energy charges (paise / kWh)			
	- Chennai metropolitan area	310	285	8.8%
	- non metropolitan areas	300	275	9.1%
	Minimum monthly charges (Rs / service)	20	20	-
LT - IIIA	Cottage and tiny industries etc.(load =< 10 hp)			
	- Fixed charge (Rs / service / month)			
	--- current transformer service (Rs / kW / month)	1	1	-
	--- other service (Rs / service / month)	30	30	-
	- Energy charge (paise / kWh)			
	--- up to 250 kWh / month	140	130	7.7%
	--- 251 to 750 kWh / month	225	210	7.1%
	--- >= 751 kWh / month	250	240	4.2%
	Minimum monthly charge (Rs / service)	30	30	-
LT - IIIB	Ice Factory, coffee grinding etc.			
	Fixed charge			
	- current transformer service (Rs / kW / month)	1	1	-
	- other services (Rs per service per month)	30	30	-
	Energy charges in Chennai Metro Area			
	- up to 750 kWh / month (p / kWh)	330	310	6.5%
	- >= 751 kWh / month (p / kWh)	400	370	8.1%
	- Minimum monthly charge (Rs / kW of contracted load)	40	40	-
	Energy charges in non-metro areas			
	- up to 750 kWh / month (p / kWh)	320	300	6.7%
	- >= 751 kWh / month (p / kWh)	390	360	8.3%
	- Minimum monthly charge (Rs / kW of contracted load)	40	40	-
	Welding	+25%		
	If connected load between 75 and 150 hp			
	- demand charge (Rs / kVA / month)	150		
	- energy charge (p / kWh)			
	--- Chennai Metro area	350		
	--- Non-metro areas	340		
LT IIIC	IT Industries			
	Fixed charge			
	- current transformer service (Rs / kW / month)	1		
	- other services (Rs per service per month)	30		
	Energy charges in Chennai Metro Area			
	- up to 750 kWh / month (p / kWh)	310		
	- >= 751 kWh / month (p / kWh)	370		
	- Minimum monthly charge (Rs / kW of contracted load)	40		
	Energy charges in non-metro areas			
	- up to 750 kWh / month (p / kWh)	300		
	- >= 751 kWh / month (p / kWh)	360		
	- Minimum monthly charge (Rs / kW of contracted load)	40		
LT - IV	Agri and Govt seed farms	nil	nil	-
	SFS scheme (Rs / hp / year)	250	250	-
LT - V	Commercial and other			

	Fixed charge			
	- current transformer service (Rs / kW / month)	1	1	-
	- other services (Rs per service per month)	10	10	-
	Energy charges in Chennai Metro Area			
	- up to 100 kWh / month (p / kWh)	385	340	13.2%
	- >= 101 kWh / month (p / kWh)	435	400	8.7%
	- Minimum monthly charge (Rs / service)	25	25	-
	Energy charges in non-metro areas			
	- up to 100 kWh / month (p / kWh)	375	330	13.6%
	- >= 101 kWh / month (p / kWh)	425	390	9.0%
	- Minimum monthly charge (Rs / service)	25	25	-
Temp supply	Lighting			
	- Rate (paise / kWh)	800	600	33.3%
	- minimum (Rs / kW / day)	35	25	40.0%
	Lavish illumination			
	- Rate (paise / kWh)	15	12	25.0%
	- minimum (Rs / kW / day)	90	70	28.6%
	Sugarcane crushing	nil	nil	-

Exhibit 3.3: Range of tariff rates

Exhibit A3.3.1: Range of tariff rates in Residential sector

State / Utility	*With effect from (date)*	*Highest monthly consumption category*		Fixed charge
		Definition (kWh/ month)	*Tariff rate in highest slab (Rs / kWh)*	
Northern Region				
- Delhi	1 Apr '98	>400	3.00	-
- Haryana	15 Jun '98	>40	3.06	-
- Himachal Pradesh	1 Sep '98	>500	1.25	-
- Punjab	29 Jul '98	>500	2.63	-
- Rajasthan	1 Nov 99	>50	2.20	-
- Uttar Pradesh	25 Jan '99	>500	2.60	-
Chandigarh	10 Nov '98	>500	2.62	-
Western Region				
- Gujarat	22 Oct '96	>200	1.87	Rs 10/ kW / month, upto 10 kW for three-phase supply
- Madhya Pradesh	1 Mar '99	>200	2.05	-
- Maharashtra	1 Sep '99	>300	5.10	-
- Goa	1 Apr '99	>400	2.25	-
- Daman & Diu	1 Apr '98	>600	2.25	-
Southern Region				
- Andhra Pradesh	1 Jan '99	>400	3.40	-
- Karnataka	1 Nov '98	>400	4.00	Rs 17 / kW / month
- Kerala	15 May '99	>500	3.55	Rs 1325 (fixed charge) plus Rs 3.75 / kWh for housing colonies of Railways, Universities, Public Institutions etc.
- Tamil Nadu	7 Jan 2000	>300	3.05	Rs 5 / service per month plus CT charges of Rs 1/ kW/ month
Pondicherry	1 Apr '99	>400	1.30	-
Eastern Region				
- Orissa	1 Dec '98	>200	2.45	-
- West Bengal	26 Jan '99	1051-1500 >1500	6.00 3.31	-
- Durgapur	1 May '99	351-500 >500	6.00 3.31	-
- Sikkim	1 May '99	>100	2.00	-
- Assam	1 Sep '99	>120	2.40	-
- Manipur	3 Aug '98	>200	2.10	-
Private Utilities				
AEC	26 Feb '98	>300	1.70	Rs10/month for 3-phase service
BSES	30 Sep '99	>350	3.38	-
BEST	15 Jul '99	>300	3.25	-
CESC	19 Oct '99	351-500 >500	5.70 3.50	-
SEC	1 May '97	>200	2.50	Rs 10/kVA/month for 3-phase service
TEC	1 Dec '98	>350	2.72	

Source: Council of Power Utilities, Summary of Tariff Schedules of Electric Power Supply Utilities in India, March 2000, New Delhi.