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Efficient Electric End-Use Devices:
The Indian Market

January 1996

prepared by
Niels R. Wolter
Resource Management Associates Inc., of Madison
Madison, Wisconsin, USA

with the support of the DSM Cell staff at
Ahmedabad Electricity Co. LTD.
Ahmedabad, India

for
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Contract Number: 386-054127-C-00-4100-00

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Preface

This report was completed under the Energy Audit Improvement Program component of the Energy Management Consultation and Training (EMCAT) Project for India. EMCAT is funded by the U.S. Agency for International Development (USAID) for which Resource Management Associates (RMA) serves as the prime contractor for project implementation.

Under this portion of the Energy Audit Improvement Program, RMA is providing information concerning the Indian market for efficient electric end-use devices to both interested U.S. and Indian parties, with the intent of supporting U.S. business activities in India and encouraging Indian energy professionals to promote energy-efficient devices in their own country. Much of this information was gathered for the demand-side management component of the EMCAT project.

This is a working document published informally by RMA. This report has been prepared in a working document format, to present the activities and findings of our ongoing efforts in a timely manner. This report has not been approved of by USAID. All opinions expressed in this report are that of the authors and RMA.

This report provides insights into Indian market but is not a comprehensive survey. The research was done in 1994 and 1995 in the cities of Bombay, Delhi, and Ahmedabad, thus it may not present a complete assessment for all of India. Exclusion of any equipment brand name, manufacturer, or supplier was not intentional. Similarly, any errors or misprints in the directory are inadvertent. The manufacturer's address, device specifications, and price data were gathered informally, primarily from product information flyers.

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General Background Information: Business Climate and Market Barriers

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1. Executive Summary

With ongoing relaxation of trade restrictions, a thriving economy, a growing middle class[1], and a population of 850 million, India has become one of the world=s most active markets. As a result of the recent economic reforms, business opportunities for U.S. firms are better now than in the last 50 years.

Yet, India=s economic growth is hampered by a both severe electricity shortage and the inefficient use of power. India has a per capita power consumption of 270 kWh per annum **B**far below the annual per capita power consumption of developed countries, which is between 8,000 and 25,000 kWh. This large discrepancy indicates the potential for future electricity demand growth in India; but India=s consumption rates also include needless end-use equipment inefficiencies which, if corrected, would reduce India=s current demand by as much as 20% to 40%.

U.S., European, and Asian firms have been entering India=s efficient electric device (EED) market. Similarly, many Indian firms are looking to develop relationships with U.S. firms to support their efforts in producing EEDs. Although India is a difficult market for foreign firms to enter, barriers are falling, especially in the power sector, where the severe power shortages and high electricity prices are increasing the demand for EEDs. The time is ripe for U.S. firms to considered entering the Indian EED market.

This report reviews current Indian business conditions and tax structures. It also presents what we believe is a fair assessment of the barriers which make the sales of EEDs difficult and discusses which of these barriers are being reduced and how interested firms may further reduce them. Finally, the market for three important groups of EEDs, motors, lighting, and residential appliances, are presented in detail.

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[1] About 200 million Indians have a standard of living comparable to that in the US.

2. Introduction

The intent of this report is to promote the use of Efficient electric End-use Devices (EEDs) in India. This report serves both U.S. EED manufacturers, by informing them of the Indian market conditions, and Indian energy professionals, by providing them with a directory of those EEDs available in India. It is hoped that this report will encourage U.S. manufacturers to enter the Indian market through such means as licensing distributors, undertaking joint ventures, establishing subsidiaries, and opening production facilities. This report includes the following components:

- An overview of the types, technical specifications, and costs of the EEDs available in India
- The addresses and contact names of some of the Indian firms currently manufacturing and distributing EEDs
- Estimates of the current and projected demand for each equipment type (e.g., incandescent light bulbs or room air conditioners) for all of India
- Estimates of the potential market demand for each EED for all of India
- A review of the barriers present in the Indian EED markets
- Recommendations concerning how market barriers may be overcome

The secondary objective of this report is to inform Indian energy professions (e.g., electric utility staff, consulting engineers, motor manufacturers and dealers, factory energy managers, engineering contractors, etc.) of the EEDs currently available in India and their benefits. This information should assist energy professionals with promoting EEDs to the Indian market. With these goals in mind, the report includes the following types of information:

- A description of each EED
- The types, technical specifications, and costs of the availableefficient end-use devices
- An estimate of the energy savings and payback period for each EED type
- The addresses and contact names of those Indian firms manufacturing and distributing EEDs
- Estimates of the current demand and future demand for EEDs
- Projections of potential demand and electricity savings for each equipment type

< A review of the barriers present in the Indian EED markets

< Recommendations concerning how these barriers may be overcome

It is not possible to present a thorough survey of all the EEDs currently available in India. Rather the AEED directory@ provides examples of the EEDs which are currently available. Thus, at best, a few specific products will be included for each equipment type. This report concentrates on lighting and motors because they have the largest potential for energy savings and many energy-efficient models are available.

This report covers the following EED categories and the relevant economic sectors where they are used:

EED Category	Economic Sector
C Motors, motor drives, soft-start controllers, belts, & rewinding	Industrial, service, and agriculture
C Lighting (lamps and ballasts)	Industrial, residential, commercial, and agriculture
C Refrigerators	Residential and commercial
C Room air conditioners	Residential, commercial, and industrial
C Power factor correction devices	Industrial and commercial

For many technology categories there are no clearly Aenergy-efficient@ models. Likewise, some devices, which are called energy-efficient in product brochures, may not be so when compared to technologies available in developed countries. It is often difficult to assess if a technology is energy-efficient unless engineering data is collected to determine its efficiency and the efficiency of the technology it replaces[2]. Within one appliance model, efficiencies can also vary significantly[3].

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[2] As the quality of engineering and the material used are improved, the efficiency of devices sold in India will also improve. At the same time, the minimum qualification needed for a device to be deemed "energy-efficient" should also increase.

[3] For example, the efficiency of one model of air conditioner, depending on the out-sourced components used, varies from an EER of 6.7 to 8.6.

This report has three principal components:

1. An overview of the Indian business and power sector climate (Section 3)

2. A discussion of the barriers to energy efficiency in India (Section 4), including

   - A description of the barriers

   - A review of how reforms in India are affecting the barriers

   - Recommendations for U.S. to minimize the barriers

3. A directory to some of the efficient electric end-use technologies available in India (Sections 5 and 6), which includes

   - An overview of each technology, including its description, market potential, savings potential, device-specific barriers, etc.

   - Names and addresses of some of the Indian firms currently producing the technology

   - Specifications, prices, and estimated energy savings and payback periods for products currently available in India

3. Background

3.1 Indian Power Supply Specifications

Standard voltages and frequencies in India are 415 and 220 volts with a frequency of 50 cycles per second. Single- or three-phase connections are used. The most common ratings are 400, 220, 132, 66, 33, 11 and 6.6 KV (this refers to capacitors, fuses, and voltage regulators). Power quality is rather poor in India. Interruptions, planned and unplanned, are common. Line voltage variation of 30% or higher is common, as are spikes and surges. Some Indian states are known for providing better power quality and reliability (i.e., Maharashtra and Tamil Nadu) than others. India uses the metric system of weights and measures.

3.2 The Indian Business Climate [4]

India is a sovereign Socialist Secular Democratic Republic. The Indian economy has become more open than at any time since the country achieved independence (1947). There are many opportunities for U.S. businesses to enter the Indian market or expand their activities and sales in India.

Indian Prime Minister Rao began the liberalization of the Indian economy during the fiscal year 1991/92. These reforms were driven largely by the intense lobbying of Indian business executives. Reforms over the last four years have included Rupee convertibility, a rationalized and simplified tax structure, simplified import licensing, reduced customs duties, lowered personal and corporate taxes, and privatized public sector firms. These reforms, principally the Government of India=s (GOI) liberal import policies, have been a boon to importers into India.

The maximum customs duty has decreased from 85% to 50%, with a minimum rate of 25%. The GOI plans to continue reducing import duties to the level of 5% to 30% on industrial inputs and less than 50% for nonessential capital goods by 1997/98.

Corporate tax rates for Indian firms have been reduced from more than 50% to 40%. The tax rate for foreign companies has been reduced from 65% to 55%; but most foreign firms have Indian subsidiaries and, thus, pay the same tax rate as Indian firms.

The GOI provides Aautomatic approval@ for foreign technology agreements (e.g., joint ventures) to ventures with up to 51% foreign equity participation. Hiring of foreign technical personnel and

[4] This section is based, in large part, on information from reports of the National Trade Data Bank, which is maintained by the US International Trade Administration.

repatriation of profits and dividends is also allowed. One hundred percent export-oriented firms are allowed to import capital goods, components, raw materials, spares, and equipment duty free. They are also allowed to purchase domestic-made capital goods, components, and raw materials without paying excise taxes.

Many Indian businesses are very interested in joint venture arrangements with U.S. firms, as well as with British, German, Japanese, Korean, and other foreign multinational firms. To operate in India, foreign firms are required to have an industrial license and an investment proposal approved by the GOI.

In the consumer goods sector (e.g., refrigerators and washing machines) customs duties have not been reduced. In fact, as of June 1994, residential appliances (or Awhite goods@) is the one sector where imports of some goods are still prohibited or limited by quotas. Consequently, U.S. firms have entered this market using alternative approaches. For example, in 1993 General Electric (GE) began a joint venture with an established Indian white goods manufacturer (Godre and Boyce) to produce refrigerators. The GE - Godre and Boyce joint venture has its manufacturing base in India and out sources many of its component needs to smaller Indian firms.

As a result of the economic liberalization of the last five years, the Indian economy is undergoing profound structural changes. Movement has been from an industrial policy of protected, government-owned and -operated, heavily regulated industries, toward the promotion of privatization and joint ventures with foreign firms, reduced government interventions (including subsidies) and general free market operation of the industrial sector.

During this transitory period, some of the protectionist governmental structure remains. For example, many firms are still government-owned and -operated. Other firms are still receiving various forms of government subsidies. In general, the Asmall-scale@ manufacturers are more heavily subsidized than the larger firms.

The overall implications for U.S. businesses of these policy changes include the following:

C Increased investment opportunities (In fiscal year 1993/94 India attracted $US 5.0 million from portfolio and direct investments.)

C An industrial and economic boom (Industrial output is anticipated to grow at a rate of as much as 10% to 15% annually for the next five years, while gross domestic product is increasing at a rate of 3% to 5% annually.)

C Reduced bureaucracy

C Improved market access

- Improved competitiveness of imported items
- Increased interest of Indian and non-Indian enterprises to engage in joint ventures
- A growing middle class
- Increased financing opportunities for all sectors.

To keep pace with population growth (2% per annum) and relieve deficiencies in the existing infrastructure, the Indian economy would need to maintain double-digit growth rates for the next 15 to 20 years.

It is feared that without vigorous growth of the private sector, tax receipts will not meet budgetary needs and will result in deficit-driven inflation. As of yet, inflation has remained moderate; the current (first eight months of fiscal year 1994/95) annual inflation rate is 10.5%. Optimism in the markets, industrial growth, and better tax compliance is keeping inflation at bay. The rapid surge in money supply from GOI expenditures and the large inflow of foreign capital however have been supporting inflation.

Indian opposition parties have claimed that the reforms are a sell-out to multinational interests. There are populist fears that the Rao government is forsaking India's economic sovereignty. As the success of the Indian economic reforms continue to provide real standard of living improvements, it is anticipated that the voice of the opposition parties will gradually be quelled.

U.S. firms interested in entering the Indian market are advised to participate in leading trade fairs in India to demonstrate their products'/firm's capabilities to potential distributors and joint-venture partners. A directory of useful contact points for more information on Indian business climate and business opportunities is included in Appendix 1.

3.3 Structure of the Indian Industrial Sector

In general, the Indian electric equipment sector can be divided into three groups: the small-scale firms, which supply local markets; the large- and medium-scale industries, which supply most Indian markets; and the large firms with joint ventures (commonly with large multinational conglomerates), which have access to almost all of India's markets.

The Indian electric motor sector demonstrates this structure well. In Ahmedabad, India (an industrial city of approximately three million people in the state of Gujarat) about 18 brands of motors are available. Approximately 12 are made by the small-scale sector manufacturers located in the area. These motors may not be available outside of the state of Gujarat; they are typically of low efficiency, quality, and cost, but the manufacturers can be very responsive to their customers. Four of the motor brands (Kirloskar, Crompton Greaves, Hindustan, and Bharat Bijlee) are made in India and are available in almost all of India. These motors are typically of good quality and moderate efficiency and cost. Two of motor brands (Siemens, ABB) are made in India under joint ventures with large, foreign, motor manufacturers. These motors are typically of good quality, high efficiency and cost. Motor dealers may often have to special-order these motors, requiring delivery times of up to three months. The small-scale sector brands currently control much of the small motor market (less than 15 hp) in Ahmedabad.

3.4 Energy Efficiency Standards and Labeling

The Central Power Research Institute works together with the Bureau of Indian Standards to develop technology energy efficiency standards. These standards are voluntary. The bureau sees their role as Acatalytic@ Bdisseminating technology efficiency information to manufacturers and customers. There were more than 200 standards in place in 1991. The standards are periodically revised and strengthened. The labeling of appliance efficiencies (or estimated annual electricity consumption) is not required by the GOI. Similarly, there is no uniform system for labeling or marking consumer goods.

3.5 Taxes: Customs Tariffs

The GOI regulates imports through the Import Trade Control Organization, which is part of the Ministry of Commerce. The Import Trade Control Organization is headed by the Director General of Foreign Trade, New Delhi, and Joint Chief Controllers are stationed in Bombay, Calcutta, and other major Indian cities.

Customs or import tariffs on foreign-made goods have steadily fallen since the beginning of India=s economic liberalization in fiscal year 1991/92. In the early 1990s, imported compact fluorescent lamps were taxed at a rate of 225%, making each lamp cost more than the average monthly family income. The maximum customs rate are gradually being reduced, to 65% in fiscal year (FY) 1994/95 and to 50% for FY 1995/96. At the same time, the minimum customs rate, which is applied to many imported electric devices and components, is also steadily declining (to 25% for FY 1995/96). Tariff rates on general machinery (mechanical and electrical), machine tools, instruments, and projects were reduced 25% for FY 1995/96. Duties on electronic components and parts were reduced from 80% to 50% in FY 1994/95.

Indian import tariffs remain high by world standards, especially for goods that can be produced domestically. With falling import duties, consumers are gaining increased product choice. Furthermore, decreasing tax rates result in increasing competition, thereby encouraging Indian firms to improve their product quality, reliability, and price and encouraging foreign firms to enter the Indian market.

Note that the GOI=s published custom tariff rates do not fully reflect the actual tariff level due to numerous exemptions. Thus the tariff levied by the GOI at the port of arrival, may differ from what the importer anticipated. Sources of information for detailed customs information are listed in Appendix 2.

3.6 Taxes: Excise Duty

A large fraction of the GOI=s budget is raised by levying excise taxes on virtually all goods sold in India. The table below, lists the excise duties for common electric devices.

Indian excise duties for fiscal year 1994/95.

Device	Excise Duty 1994/95
Motors	10%
Pumps	10%
Fans	10%
Motor Drives	10%
Air Compressors	10%
Refrigeration Compressors	25%
Light bulbs	10%
Light fixtures	10%
Air Conditioners	40%
Refrigerators	20%

3.7 Taxes: State and Local Tariffs

State and local taxes are variable. For example, the state and local tax rates in the city of Ahmedabad in the state of Gujarat are as follows:

- The state sales tax is 14% for refrigerators, lighting systems, motors and motor components while air conditioners are exempted

- The city levies local taxes of 5% on all electric technologies

4. Barriers

4.1 Barriers Limiting the Penetration of Energy-Efficient Technologies

There are many barriers limiting the sales of EEDs in India. These barriers are similar to the problems seen in most developing countries. Many of the barriers are currently being overcome, but much work toward reducing them remains. Many of the barriers listed below are based on the experiences of RMA staff in India. Barriers which are specific to a particular EED are discussed in the EED directory (Section 6).

Barrier #1 **B***The limited availability of EEDs.*

< Indian firms may not be interested or able to manufacture some EEDs.
< Indian firms may not be able to obtain the rights to manufacture some EEDs.
< The raw materials or equipment needed to manufacture an EED may not be available.
< An EED may not be carried by dealers because of its high price.
< An EED may not be stocked by a dealer because of poor sales expectations.
< Inadequate transportation infrastructure makes distribution of EEDs difficult.
< Delivery times for EEDs are commonly longer than for standard-efficiency equipment.
< The inaccessibility of spare parts and maintenance, particularly for complex, imported technologies (e.g., a computer-controlled energy management system).

Barrier #2 **B***The lack of customer awareness of EEDs and energy auditing practices.*

< Neither Indian utilities nor Indian manufacturers have effectively promoted demand side electricity savings.
< There are no mandatory energy efficiency standards.
< Because of the lack of efficiency standards and/or reliable engineering specifications, it is often not apparent which devices are efficient.
< Most utility customers typically do not understand the basic principles of energy economics such as life-cycle costs, payback period and internal rate of return. Nor do they understand the need for and benefits resulting from energy audits.
< Most industrial and commercial enterprises do not have an energy management/engineerig staff person(s) who would identify, support, and implement energy efficiency measures. Nor do they typically hire energy auditing firms to do this work.
< Energy auditing equipment, needed to identify successful EED application points, is not typically available to energy management personnel.
< Electricity prices in the residential and agricultural sectors are subsidized, thus lengthening the payback period of EED investments.

Barrier #3 **B***High EED capital cost:*

< Many customers, especially those in the small-scale industrial, commercial, and lower income residential sectors, have limited financial resources. They normally choose the

device that meets their basic needs and has the lowest initial capital cost, thereby commonly choosing the most inefficient (or even used) device.

- Potential customers and financial institutions require rapid payback periods (less than two to three years) on end-use investments.
- The general lack of capital for EED financing has limited EED penetration. Capacity expansion investments are commonly preferred because they have higher rates of return than efficiency investments.
- Interest rates are up to 20% per annum[5]. This rate encourages many purchasers to focus on the first cost of the measure rather than its life-cycle cost.
- Innovative methods of financing have not been used for EED sales.
- Customs and excise duties do not distinguish between standard-efficiency and high-efficiency appliances.
- High customs duties on imported EEDs, EED components (e.g., high flux motor magnets) or specialized raw materials (e.g., cold rolled electrical steel) drive up their costs.
- Because of the limited sales of EEDs, the economies of scale cannot be taken advantage of to reduce their costs.
- The EEDs which are available are commonly of premium quality with extra options. Thus, customers pay a high price for efficiency, quality, and options.
- No effective incentive programs have been instituted by Indian utilities, financial institutions, or the GOI to reduce the cost of EEDs or barriers limiting EED sales.

Barrier #4 **B***Difficulties of importing devices and components into India*

- The customs rate assessment process is seemingly subjective, highly bureaucratic, and may result in long delays. For example, rate assessments can be based on the transportation mode used to import the equipment or on a written description of the equipment rather than on a visual inspection.
- It is difficult to obtain information from the GOI regarding current import duty rates.
- General difficulties in communication with the import customs authority make it difficult to effectively track goods through customs.

Barrier #5 **B***Poor power quality and reliability is hard on delicate electric technologies*

- Line voltage can vary by 30% (particularly in rural areas). Spikes, surges and brownouts are also very common. Under these conditions, some EEDs such as high-pressure sodium lamps may not operate, or may rapidly burnout.

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[5] The economic liberalization has resulted in unprecedented investment opportunities and demand for hard currency. The investment climate is competitive, interest rates are high, and expected payback periods are short. As the economy stabilizes, both requisite payback periods and interest rates should decline. Thus, currently only the most cost-effective energy efficiency investments are currently being undertaken.

- < Electricity technologies often need to be of a robust design or oversized to operate with the poor power quality[6]. Such modifications decrease efficiency and increase costs.
- < In the energy professionals= community there is some misinformation concerning which EEDs will operate for their specified lifetime under the existing power quality conditions.

*Barrier #6 **B**Poor reputation of some Indian EEDs*

- < Some manufacturers have made devices of poor quality that have not met customer expectation, thereby tarnishing the name of some device types (e.g., electronic-tube, fluorescent ballasts) and making customers reluctant to purchase improved versions of the device.

*Barrier #7 **B**Lack of large equipment renovation and used equipment markets:*

- < Energy-using equipment in India has a very long in-service life. Old, typically inefficient equipment is fixed, renovated, and components recycled rather than replaced by new efficient devices. Electric motors which are more than 25 years olds and have been rewound several times are common.
- < A large, used equipment market provides old, often rebuilt, and typically very inefficient equipment to those with limited capital (e.g., the small-scale industrial sector).

4.2 Recent Progress Toward Overcoming the EED Barriers

The barriers listed above are becoming less significant. The recent changes in the economy, a serious and growing power shortage, and rapidly increasing electricity prices have been the primary reasons for the increasing interestin, availability and penetration of EEDs.

A. Electricity Price Increases

Over the last decade, electricity prices have been increasing more rapidly than general inflation. The average power tariff for the high-tension industrial sector is 2.5 Rupees/kWh (or 8 cents/kWh). Commercial sector rates are about 3.5 Rupees/kWh (or 11 cents/kWh). The cost of new generation is also rapidly increasing. Ahmedabad Electricity Co. LTD. (AEC) a privately-owned utility in the city of Ahmedabad, estimates their cost of new generation and transmission and distribution expansion is 60,000 Rupees/kW (or $US 2,000/kW). Also, in some

[6] For example, refrigerator motors typically have extra copper mass to prevent them for burning out during power irregularities.

Indian states electricity subsidies are decreasing and pricing is becoming more cost-based. These changes create a climate for the following actions:

< Encourage plant managers to take a closer look at their energy consumption patterns and increase the priority of energy efficiency investment

< Increase demand for energy-efficient products (for example, over the last five years 20 firms have begun manufacturing energy-efficient lamps)

< Reduce energy efficiency investment payback periods. With the cost increases for fuel, power plant construction, etc., many demand-side efficiency measures are now less expensive than supply-side options.

B. Electricity Shortages and the Indian Economic Boom

India has long suffered under a shortage of electric power. Now, with the economic boom, the supply gap is growing, and plant managers are less willing to accept power interruptions. It is estimated that the peak power deficit was more than 20% in 1994, reducing industrial output by about 5%. As a result, there has been a push to build new, utility-owned power plants and captive power plants (plants operated by a factory to serve its own load) and to promote end-use energy efficiency (with the emphasis on the supply-side options).

The State government of Maharashtra's recent annulment (and now renegotiation) of a contract with Enron Development Corporation to build the 695 MW Dhabol power plant, will only slow the rate of generation capacity growth and increase India's need for EEDs.

C. Economic Reform

With the opening and vitalization of the Indian economy, foreign producers of EEDs have begun entering the Indian market. The reforms under the Rao government have led to the following improvements:

< Encouraged joint ventures between Indian and foreign firms and opened the market to multinational corporations, thereby promoting technology transfer and improving the availability and quality of EEDs

< Gradually decreased customs and excise tariffs, thus increasing the competitiveness of foreign-made or -sourced EEDs and EED components

< Made banking, accounting activities more transparent

< Reduced taxes on multinational firms

< Greatly increased the rate at which foreign capital is entering India and led to increasing foreign currency reserves for foreign EED or EED component purchases

< Ended the dual exchange rate system and improved the convertibility of the Rupee.

The reforms have also resulted in an economic boom, consequently increasing demand by the flourishing industrial and commercial sectors and the middle class for high-quality consumer and industrial products and machinery. Concurrent with this, the Indian economy is becoming increasingly electrified and is moving alway from biomass and coal fuels. This is most evident in the residential sector with the rapid penetration of electric appliances and lighting.

Not only is the economy growing, but so is the number of consumers. The Indian population is anticipated to surpass China as the world=s largest market in the next century. The foreign firms are aware of India=s huge market potential and are rapidly entering the India market, often with complete lines of products including energy-efficient products,

D. Availability of EEDs

As documented by the EED directory (Section 5), many of the standard, energy-efficient devices available in developed countries are now available in India. New types of EEDs and manufacturers and suppliers of EEDs are continually entering the Indian market. These EEDs include compact fluorescent lamps, electronic ballasts, energy-efficient motors, and adjustable speed drives.

E. Energy Efficiency Institution Building

With the rapid electricity price increases and the significant electricity shortages, there has been increased interest in demand-side management (DSM) at utilities, enterprises and the GOI. Some utilities have begun making the first steps toward incorporating DSM into their normal business practices[7]. The GOI has formed institutions (e.g., the Energy Management Center [EMC], and the National Productivity Council [NPC]) to promote energy efficiency. Multinational organizations and other aid organizations have been providing training and technical support to

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[7] Time-of-day pricing has been instituted at some of the more progressive Indian State Electric Boards (Maharashtra and Tamil Nadu). A DSM pilot project is being developed at a privately owned utility (AEC). The State Electric Board of Uttra Pradesh is installing direct-load control systems on agricultural pump sets.

begin DSM, integrated resource planning (IRP), energy pricing, engineering economics, and energy audits, and are providing energy auditing instruments and supporting demonstration projects. Some utilities such as AEC and the Bombay Suburban Electrical Supply (BSES) have recently instituted DSM programs.

4.3 How U.S. Firms Can Overcome Indian EED Barriers

With large electricity savings potential in every sector, increasing electricity rates and labor rates, India should be a prime market for EED sales. But as discussed above, many barriers limit the penetration of EEDs. For firms attempting to enter or bolster their presence in the Indian EED market, the following recommendations should be considered.

A. Develop Collaborative or Joint Venture Relationships with Indian Enterprises

U.S. product designs, production schedules, progressing through bureaucracy, marketing strategies, dealer relationships, etc., must be adjusted to the Indian situation. By using the infrastructure and local knowledge of an existing well-respected Indian firm and their personnel, a U.S. firm can much more rapidly and more successfully enter the Indian market. Relationships may include everything from using an Indian firm=s dealer network to distribute an imported device, to granting an Indian firm the rights to produce a specific good, or to jointly develop a new product line for manufacture in India[8]. The U.S. State Department and Indian Associations (noted in Appendix 2) can help U.S. firms identify reputable Indian firms.

Indian customers are brand conscious and generally consider Indian-made goods to be of inferior quality compared to imported Aname brand@ goods. It is recommended that firms with a well-recognized name, use that name. Also the AMade in the US Label@ is a selling point in India. For large, U.S. firms, it may be preferable that their name is combined with the name of a respected Indian firm. For example, General Electric, U.S., has joined with APAR lighting of India, to form General Electric/APAR. For smaller U.S. firms collaborating with Indian firms for the production of EEDs, the relationship is often noted by a comment on brochures and advertising. Indian customers generally respect collaborations and feel they produce a better product.

For foreign firms with a well-known name, it may be dangerous to enter the Indian market alone. The venture may be used in the Indian political morass to push a political (Aanti-imperialist@) agenda. Nationalist feelings have been engendered with the increasing presence of large foreign corporations in Indian. An example of this is the recent closing of the first Kentucky Fried Chicken restaurant in Bangalore India by city officials following pressure from adversarial political

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[8] This is particularly crucial for firms wishing to enter the Indian white goods market, because their imports are restricted.

groups who claimed the company=s chicken formula would expose customers to cancer and other ailments.

B. Work with Respected Indian Institutions to Develop DSM Ally Relationships

Many institutions in India have the objective of improving the energy efficiency of the Indian economy. These institutions include the State Electricity Boards, the few privately held utilities (BSES, AEC, and Calcutta Electric Supply Company), the GOI, environmental groups, industrial trade organizations, etc. By working together with these institutions as allies, U.S. EED firms could more effectively enter and expand markets. The U.S. State Department and Indian Associations noted in Appendix 2 can help U.S. firms identify reputable allies.

For example, AEC is currently developing motor ally relationships with the manufacturers of energy-efficient motors. AEC will undertake a large testing, information, and education program to promote energy-efficient motors. AEC will promote the efficient motors of qualified manufacturers in their marketing program. In turn, the motor manufacturers will support the DSM efforts of AEC (perhaps by reducing motor prices to AEC customers, insuring prompt delivery, and providing high-quality, after-sales service).

C. Using Educational Sales and Promotion Strategies

Energy management is largely an ignored field in India, primarily in the commercial, residential, and small-scale industrial sectors. Thus, any EED promotion should have a large component of education. If the customer believes in the benefits of EEDs, then the EEDs will more rapidly penetrate the Indian market. For example, sales strategies could use simple methods to not only show payback periods but how payback periods are calculated. Educational strategies could include presentations to trade associations which focus on energy economics rather than the firm=s products, developing public service informational campaigns, working with the university and vocational systems to improve energy management education, and supporting the informational activities of utilities and other DSM advocates.

D. The Importance of EED Demonstrations

Given the current general lack of energy management training, customers often rely on the actions of their competitors to guide their own actions. The Akeep-up-with-the-neighbors@ attitude is common in India. Also, in a culture where bribes are common, both testimonials and test results are not trusted, until customers can see the results for themselves. Thus, if a demonstration is done at one respected firm (and the demonstration shows good results), then other firms may follow with similar investments, almost irrespective of its payback period. Strategies could be developed where leading firms are given an incentive if they are willing to be a demonstration site.

E. Overcoming EED Performance, Quality and Reliability Fears

Some EEDs (e.g., electronic fluorescent ballasts) have been dogged with quality and reliability problems. This is for two main reasons: first, the components used are of an inferior quality or design, and second, the EEDs are not properly designed for the variable power characteristics of the Indian electrical systems.

Indian firms have had a difficult time convincing customers of a device=s quality and reliability. They have tried three approaches to alleviate their customer=s apprehensions. The most common strategy is to provide testimonials from satisfied customers (the testimonials are usually in the form of purchase orders and letters of satisfaction shortly after the EED was purchased). Second, the test results from an Indian testing laboratory may be used to document that the device saves energy. But the laboratory results are commonly doubted by the customer. Third, some EED manufacturers are beginning to offer guarantees.

EED customers are unsure of the qualifications of the various Indian product test laboratories. One way to circumvent this would be to have the EED recommended by a utility group (e.g., a State Electricity Board) that has evaluated and approved a given EED. This could be done through a DSM trade ally relationship.

Customers tend to believe performance specifications noted in product brochures of EEDs produced by large national firms with foreign, joint-venture partners (e.g., Siemens/Bharat Biljee or General Electric/APAR). Customers doubt the performance specifications, when available, of products produced in the Indian small-scale industrial sector. Having a Areputable@ test laboratory certify the performance of devices made by the small- and medium-sized firms is more critical than for devices made by large, well-recognized firms. By offering EED warrantees or establishing fixed-fee maintenance contracts, the customer=s quality and reliability fears could be quickly overcome.

F. Using Innovative Financing Methods

Indian customers are commonly cash poor and are often forced to purchase the option with the lowest first cost, rather than the lowest life-cycle cost. This is particularly true in the residential, commercial, and small-scale industrial sectors. By using innovative methods of financing (e.g., lease-to-own and performance contracting), this barrier could be reduced.

Lease-to-own schemes have been successful in India and should be a good method of encouraging some EED sales. Lease-to-own financing has recently been introduced in India to sell residential appliances (e.g., color TVs) and motor scooters. Performance contracting, where a private company purchases and installs EEDs and then takes their payment from the savings accruing to the customer, is yet to be widely implemented. Energy service companies (ESCOs) typically undertake performance contracts. Very few ESCO=s are currently operating in India, and only a few more are in the initial stages of formation[9]. EED firms may consider developing internal, or supporting external, ESCOs and their performance contracting activities.

G. Responsive Service and Sales Departments

Based on discussions with Indian industrial managers, they commonly complain that foreign and large national Indian firms (which are typically the firms manufacturing the most efficient technologies) are not very responsive to their customers= after-sales needs. After-sales needs include equipment servicing, repairs, calibrations, and warranty work. Meanwhile, some firms producing devices in India are more responsive to the after-sales needs of their customers (these are typically the less efficient technologies). In an industrial or commercial setting, where down time can be very expensive, a rapid repair and servicing response time is vital to the customer and may be their first consideration when choosing between brands.

This is also the case for the time needed for dealers to fill EED orders. In some cases, the dealers of imported or even some national brands require several months to deliver an EED, while the local brands can be delivered in a few days. Thus, for emergency technology replacement needs, customers will typically rely on locally made, commonly inefficient technologies. For example, to order an energy-efficient motor in the city of Ahmedabad can take from a few weeks to three months, while locally made, inefficient motors can often be ordered and received on the same day. If EED firms are more responsive to the after-sales needs and reduce delivery times to their customers, the EED will be more competitive.

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[9] The author knows of four Indian firms are at various stages of developing ESCO capabilities, including the INTESCO - Bhoruka Limited (phone number 91 80 559 7814), Thermax (with the U.S. firm Energy Performance Systems), Tata Consulting (with the U.S. firm Energy Masters) and Crompton Greaves (with the U.S. firm Forbes Marshall).

Efficient Electric End-Use Devices: The Indian Market

The Energy Efficient Device Directroy

January 1996

prepared by
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Resource Management Associates Inc., of Madison
Madison, Wisconsin, USA

with the support of the DSM Cell staff at
Ahmedabad Electricity Co. LTD.
Ahmedabad, India

for
United States Agency of International Development
under
The Energy Management Consultation and Training (EMCAT) Project for India

Contract Number: 386-054127-C-00-4100-00

5. Indian Energy-Efficient Device Directory

Explanation

The EEDs included here were chosen based on their large savings potential and their wide applicability across the Indian economy. The EEDs included in the report are proven technologies, widely used, available in India, with high implementation repeatability.

Most of the information on the EED data sheets is from company brochures, product flyers, interviews, data requests, and surveys. Most manufacturers were sent data sheets and surveys to make the necessary corrections and fill in missing information. Only a few data sheets and surveys were returned. Manufacturers were also asked to supply sales data and forecasts; again, few firms responded.

Three notations are used throughout the directory for missing data and information.

< Where no information was supplied the ANIS@ (no information supplied) notation is used.
< Where the technology was not available, the notation ANA@ (not available) is used.
< Where calculations could not be made, because of a lack of information, the column was left blank.

Note that EED prices are negotiable at the time of sales. The prices noted in the directory are list prices. The actual sales price may be up to 25% less than the listed price. The dates of the price lists are included when available.

Estimated Simple Payback Calculations for Replacement and Retrofitted EEDs

Estimated simple payback periods for replacement EEDs are based on incremental capital costs. That is, the cost of the EED includes only the cost differential between the standard-efficiency and the high-efficiency EEDs. Applying incremental costs makes sense when an end-use technology needs to be purchased and the customer has the choice between buying a standard-efficiency technology or the high-efficiency technology. In this case, the cost is the cost difference or the incremental cost. For example, when a ventilation fan motor burns out, it can either be replaced by a standard-efficiency motor or a high-efficiency motor. If the high-efficiency motor is chosen, the cost of the upgrade is the price differential. Note, that in cases where the EED costs less than the standard-efficiency technology, the incremental cost is negative.

For EEDs which are added, or retrofitted, to a system in lieu of replacing an existing device, full costs are used. An example is an adjustable speed motor drive. Very few motor applications in India have ASDs, thus if they are added, nothing is replaced and the EEDs capital cost is equal to the ASD=s full cost.

Simple payback is calculated by dividing the capital cost of the EED by the annual value of the electricity savings. It is assumed that the value of electricity is 2.5 Rupees/kWh (or about 8 U.S. cents/kWh). The simple payback calculation does not include any taxes. Had taxes been included, payback periods would be slightly longer. The simple payback calculation does not take into consideration potential, electric-demand cost savings, improvements in product quality, reduced emissions, increased technology life, discount rates, inflation, nor operation and maintenance costs. In most cases, the incremental installation, operation, and maintenance costs are equal to zero. Installation costs are not included in the payback calculation. For lighting measures, operation and maintenance costs (i.e., lamp replacement capital costs only) are included in the simple payback calculation.

The device specific assumptions used to estimate energy savings and payback periods are listed in a section entitled AAssumptions used for Incremental Cost and Payback Calculations@ directly preceding the company-specific device descriptions.

Device Population Estimates

For each device type, estimates of the number of currently operating, standard-efficiency devices were made by the author. This information is not readily available. The following steps were taken to estimate device 1994/95 populations:

- C Estimates of the electricity consumption by each end-use category and device type were made for each economic sector (these estimates are largely based on end-use surveys completed for various cities of India and from experiences in other developing countries)

- C The annual consumption for each standard-efficiency device was made for each economic sector based on average size (watts, efficiency, and annual hours of use)

- C The device=s population (for each economic sector) was determined by dividing the estimated consumption of each device type across all of India by the estimated, average annual consumption of a single device.

Current Eligibility of Standard-Efficiency Devices and the Current Penetration of EEDs

The estimates of 1994/95 eligibility and EED penetration are based on reports, discussions with energy professionals, experience in the U.S. and developing countries, and the judgement of the author. EED penetration is in general very low.

Technical EnergySavings Potential

Technical energy savings potential is defined as the total India-wide savings which would be achieved if all eligible standard-efficiency devices operating in 1994/95 were replaced by or retrofitted with EEDs. When determining technical savings potential, all eligible devices are replaced/retrofitted regardless of whether the conversion is cost-effective.

The technical energy savings potential for each end-use category is primarily dependent on the numbers of each device currently operating in India. The technical energy savings potential is then determined by simply multiplying the savings per EED with the estimated number of operating standard-efficiency devices plus the estimated fraction of technologies which could be replaced or retrofitted (considering physical constraints only).

Efficient Electric End-Use Devices: The Indian Market

Energy Efficient Motors and Motor Components

January 1996

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5.1 Energy-Efficient Motors And Motor Components

A. Energy-Efficient Electric Motors

Technical Description:
Indian-manufactured motors are similar to those utilized in the industrial sectors of developed countries. Efficient motors are made with more exacting attention to detail (e.g., high mechanical tolerances and exact balancing of the motor shaft) and improved materials (e.g., silicon steel, cold rolled electrical steel, and high flux magnets), thereby decreasing losses. Indian efficient motors typically have an efficiency of a fraction of a percent to a few percent less than the efficient motors made in developed countries. Typically Indian-made energy-efficient motors have a greater core length and thicker core windings.

Energy Savings:
The efficiency difference between a new, Indian-made, standard-efficiency motor and a new, efficient motor made by the large-scale sector (i.e., firms like Crompton Greaves and Kirloskar) ranges from 4% to 1%. Efficiency gains are less for larger motors. Energy savings will be greater, by up to 5%, when the Indian-made, energy-efficient motors are compared to motors produced by the small-scale sector manufacturers. These savings are virtually guaranteed at any motor application point.

Savings can be increased at applications where the motor replaced is significantly oversized, and thus operating below its efficient window (less than about 65% loading). By matching the task with the motor size and installing an efficient motor, savings of up to 20% are commonly realized.
Capital Costs:
In India, as well as the U.S., the cost of high-efficiency motors is 15% to 20% greater than the cost of standard-efficiency motors. Low-efficiency models made by the small-scale sector cost approximately 10% to 15% less than the standard-efficiency motors.

1995/1996 Excise Tax: 10%

Estimated Simple Payback Period:
The cost of the energy used by a motor in one year is typically greater than its initial purchase cost, thus efficiency improvements typically have rapid payback periods. Estimated payback

[10] This assumes that the motors operate 3,000 hours a year at 75% of full load.

periods range from six months to one year depending on motor size[10].

Device Population Estimate:

(units: 1,000 motors)

	motors	pumps	air & refrigeration compressors	fans
Industrial sector	2,700	350	120	400
Service sector	-	120	-	-
Agricultural sector	-	9,500	-	-

Current Penetration of Efficient Devices:

Energy-efficient motors account for less than 1% of the motor sales in India (ACEEE, 1995).

Estimated Eligibility:

We estimate that more than 95% of the Indian motor stock is eligible to be replaced by efficient motors. 15% to 25% of the motor stock is estimated to be significantly oversized and could thus benefit from both downsizing and motor efficiency improvements.

Technical Energy Savings Potential:

	motors	pumps	air & refrigeration compressors	fans
Industrial sector				
replacements (1000 motors)	2,000	265	85	300
savings (Gwh)	1,300	650	400	450
Service sector				
replacements (1000 motors)	-	90	-	-
savings (Gwh)	-	190	-	-
Agricultural sector				
replacements (1000 motors)	-	7,200	-	-
savings (Gwh)	-	1,700	-	-

[10] This assumes that the motors operate 3,000 hours a year at 75% of full load.

TOTAL				
replacements (1000 motors)	2,000	7,555	85	300
savings (Gwh)	1,300	2,340	400	450

Device Population Forecast:
Electric motors are used primarily by the industrial and agricultural sectors. The industrial motor population is thought to grow in pace with the growth of the industrial sector. Recent annual electricity consumption growth rates for the industrial sector have ranged from 4% to 6%. The number of motors is estimated to be growing at a somewhat faster rate as the Indian industrial sector becomes increasingly automated.

The 1995 market for energy-efficient pumps was estimated by the US&FGS (1994) to have a value of $US 375 million.

The number of pump motors in the agricultural sector has been increasing at a rate of 5% to 10% annually (TERI, 1995). Currently, electricity prices in the agricultural sector are heavily subsidized. If agricultural electricity prices were to reflect true costs, tariffs would increase by approximately 300% (AEC, 1994). With such a price increase, pump motor use and purchases would be expected to plummet.

Device-Specific Barriers:
The habit of Indian energy professionals and factory management is to rewind a motor rather than replace it. This is largely because rewinding costs one-tenth to one-twentieth the cost of a new motor. New motors are only considered for new installations, or when an old motor can no longer be rewound/repaired.

Some energy professionals feel that the poor power quality of the Indian power grids (e.g., spikes, surges, and frequency problems) severely reduces the life of motors. Thus, they tend to prefer less expensive motors (i.e., standard-efficiency motors) and motors which are oversized. This limits the sales of properly sized, energy-efficient electric motors, and increases motor consumption.

Efficient motors are available in India, although in limited number and in limited models (e.g., size, rpm, number of poles, mounting brackets). Some raw materials required to manufacture energy-efficient motors (e.g., properly enameled winding wire, grain-oriented cold rolled steel) are not currently made in India, and foreign sources are expensive.

Motor dealers rarely stock energy-efficient motors. Special orders, often taking from three weeks to three months, are required, acting as a further disincentive to customers.

Comments:

Motors made by the dozens of firms in the small-scale sector are an important source for small (less than 20 hp) motors. In 1987, the small-scale sector supplied 20% of India's motor needs. The small-scale sector is known for producing inexpensive motors with low efficiencies and power factors.

The International Institute for Energy Conservation (Storm et. al., 1992) suggest that US made motors have a competitive advange in many foreign markets based on their advanced technology, high quality, high efficiency and therefore reduced lifecycle costs.

Assumptions Used for Incremental Cost and Payback Calculations:

The savings estimate is based on: 1) standard-efficiency motor ratings at 3/4 full load; 2)with an efficiency of: 75% efficient for 2.2 kW; 84% efficient for 5.5 kW; 86% efficient for 9.3 kW; 87% efficient for 15 kW; 90.5% efficient for 30 kW; and 91.5% efficient for 55 kW motor; 3) for 3,000 hours/year; and 4) a power tariff of 2.5 Rupees./kWh.

All prices are for nominal 1,500 RPM, three-phase, four-pole, totally enclosed fan-cooled motors. Prices (taxes not included) of standard-efficiency motors are: 4,500 Rs. for 2.2 kW; 8,000 Rs. for 5.5 kW; 14,870 Rs. for 9.3 kW; 19,450 Rs. for 15 kW; 40,560 Rs. for 30 kW; and 80,860 Rs. for 55 kW motors (prices from Kirloskar 3/4/95). Installation and maintenance cost assumed to be equal for the standard- and high-efficiency motors.

#1
Energy-Efficient Motors
Supplier: Kirloskar Electric
P.B. No. 5555
Malleswaram West
Bangalore 560 055
phone: 332-2111 or 332-2771
fax: 080-332-2469

Technical Specifications :
Three-Phase Induction Motors: for 4-pole motors
Anticipated Life: over 15 years
Rating: 0.55 to 150 kW
Voltage: 415 +/-10%
Frequency: 50 Hz +/- 5%

Rating (kW)	2.2	5.5	9.3	15	30	55
horse power:	3	7.5	12.5	20	40	75
Full Load RPM:	1400	1440	1450	1450	1470	1480
Full Load Efficiency:	84%	87.5%	91.5%	92%	92.5%	93.8%
3/4 Load Efficiency:	84%	87%	91.5%	91.5%	92.5%	93.8%
Full Load Power Factor:	0.80	0.83	0.88	0.87	0.88	0.89
3/4 Load Power Factor:	0.71	0.78	0.85	0.84	0.85	0.87

Energy Consumption

Savings kWh/year:	710	510	1460	2110	1610	3320
Savings Rupees/year:	1770	1270	3660	5270	4030	8290
Payback years:		1.1	0.9	0.8	2.2	2.6

Estimated Price in Rupees (based on information from AEC)

Price:	NIS	9,345	18,058	23,621	49,291	102,458
Taxes:		935	1,806	2,362	4,929	10,246
Incremental Price:		1,345	3,188	4,171	8,731	21,598

Availability:

Sales offices in: Ahmedabad, Aurangabad, Bangalore, Belgaum, Bhopal, Bhubaniswar, Bombay, Calcutta, Coimbatore, Cochin, Durg, Guwahati, Hyderabad, Indore, Jabalapur, Jaipur, Jamshedpur, Kanpur, Ludhiana, Madras, Meerut, Nagpur, New Delhi, Patna, Pune, Ranchi, Surat, and Vishakapatanm.

#2

Energy-Efficient Motors

Supplier: Crompton Greaves: Motor Division
Dr. E Moses Road
Worli Bombay 400 018
phone: 495 1983 or 495 1973 or 495 1809
fax: 022-495 0485

contact person: Mr. P. N. Salaria, Chief Design Engineer

Technical Specifications:

Three-Phase Squirrel Cage Induction Motors: for 4-pole motors
Anticipated Life: over 15 years
Voltage: 415 +/-10%
Frequency: 50 Hz +/- 5%

Rating (kW)	2.2	5.5	9.3	15	30	55
horse power:	3	7.5	12.5	20	40	75
Full Load RPM:	1440	1450	1470	1450	1475	1475
Full Load Efficiency:	84.1%	86.9%	91%	91.5%	93.5%	94.2%
3/4 Load Efficiency:	84.1%	86.9%	90.5%	91%	93%	94%
Full Load Power Factor:	0.87	0.86	0.84	0.85	0.86	0.86
3/4 Load Power Factor:	0.83	0.89	0.80	0.81	0.82	0.82

Energy Consumption

Savings kWh/year:	715	490	1,210	1,705	2,005	3,600
Savings Rupees/year:	1,785	1,230	3,020	4,260	5,010	8,990
Payback years:			1.5	1.4		

Estimated Price in Rupees (list prices of 3/4/95)

Price:	NIS	NIS	19,330	25,250	NIS	NIS
Taxes:			1933	2525		
Incremental Price:			4,460	5,800		

Availability:

Branch and regional offices in the cities of: Bombay, New Delhi, Calcutta, Madras, Lucknow, Jalandhar, Jaipur, Guwahati, Patna, Bhubaneshwar, Ahmedabad, Indore, Nagpur, Baroda, Pune, Bangalore, Secunderabad, Cochin, and Coimbatore.

#3

Energy-Efficient Motors

Supplier: Bharat Bijlee
Electric Mansion, 6th floor
Appasaheb Marathe Marg,
P.B. No. 19103,
Prabhadevi Bombay 400 025

phone: 430 6237
fax: 91 22 437 0624

Contact Person: Vijay Pail, Sales Executive

Technical Specifications:

Three-Phase, Squirrel Cage Induction Motors: for 4-pole motors
Anticipated Life: over 15 years
Voltage: 415 +/-10%
Frequency: 50 Hz +/- 5%

Rating (kW)	2.2	5.5	9.3	15
horse power:	3	7.5	12.5	20
Full Load RPM:	1430	1445	1450	1450
Full Load Efficiency:	83%	87.5%	90.5%	90.8%
3/4 Load Efficiency:	82.5%	87%	91%	91.5%
Full Load Power Factor:	0.77	0.83	0.88	0.88
3/4 Load Power Factor:	0.69	0.76	0.87	0.87

Energy Consumption

Savings kWh/year:	561	495	1,395	2025
Savings Rupees/year:	1,403	1,238	3,488	5,063
Payback years:		1.6	1.1	1.0

Estimated Price in Rupees (based on information from AEC)

Price:	NIS	10,012	18,606	24,312
Taxes:		1,001	1,861	2,431
Incremental Price:		2,012	3,736	4,862

Availability

Sales offices in the cities of: Bombay, Ahmedabad, Pune, Indore, Calcutta, Guwahati, New Delhi, Ludhiana, Madras, Bangalore, Secunderabad, and Kerala.

Comments:

Have a joint venture agreement with Siemens
Bharat Bijlee provides smaller motor sizes (<15kW)

#4

Energy-Efficient Motors

Supplier: Siemens
Electric Mansion
1086, Appa Saheb Marathe Marg,
Prabhadevi Bombay 400 024
phone: 430 1548
fax: 91 22 422 8828

Contact Person: Y. Somalwar, Senior Executive-Marketing

Technical Specifications: Superbreed TEFC Cage Motors

Three-Phase, Squirrel Cage Induction Motors: for 4-pole motors
Anticipated Life: over 15 years
Voltage: 415 +/- 6%
Frequency: 50 Hz +/- 3%

Rating (kW)	15	30	55
horse power:	20	40	75
Full Load RPM:	1445	1465	1475
Full Load Efficiency:	89	92	93.5
3/4 Load Efficiency:	NIS	NIS	NIS
Full Load Power Factor:	0.84	0.85	0.85
3/4 Load Power Factor:	NIS	NIS	NIS

Energy Consumption

Savings kWh/year:	900	1,350	2,475
Savings Rupees/year:	2,250	3,375	6,188
Payback years:	instant	<0.1	instant

Estimated Price in Rupees (list prices of April, 1995)

Price:	19,440	40,570	80,830
Taxes:	1,944	4,057	8,083
Incremental Price:	-10	10	-30

Availability:

Sales offices in the cities of: Bombay, Ahmedabad, Calcutta, Delhi, Madras, Bangalore, and Secunderabad.

Comments:

In joint-venture with Bahrat Bijlee
Siemens provides larger motor sizes (>11 KW)

#5

Energy-Efficient Motors

Supplier: Asea Brown Boveri Ltd. (ABB)

Western Regional Office
Vaswani Chambers
264/265 Dr. A.B. Road
Worli, Bombay 400 025

phone: 430 8231
fax: 91 22 430 0143

Technical Specifications: HX Motors

Three-Phase, Squirrel Cage Induction Motors: for 4-pole motors
Anticipated Life: over 15 years
Voltage: 415 +/- 6%
Frequency: 50 Hz +/- 3%

Rating (kW)	2.2	5.5	9.3	15	30	55
horse power:	3	7.5	12.5	20	40	75
Full Load RPM:	1415	1440	1450	1450	1470	1475
Full Load Efficiency:	78	86	88	90	92.5	93.5
3/4 Load Efficiency:	NIS	NIS	NIS	NIS	NIS	NIS
Full Load Power Factor:	0.81	0.81	0.81	0.82	0.83	0.83
3/4 Load Power Factor:	NIS	NIS	NIS	NIS	NIS	NIS

Energy Consumption

Savings kWh/year:	198	330	280	225	1,800	3,300
Savings Rupees/year:	495	825	700	563	4,500	8,250
Payback years:	4.1	4.3	10.7	17.4	4.5	5.6

Estimated Price in Rupees (list prices of 12/8/94)

Price:	6,510	11,550	22,370	29,220	60,720	126,660
Taxes:	651	1,155	2,237	2,922	6,072	12,666
Incremental Price:	2010	3,550	7,500	9,770	20,160	45,800

Availability:

Regional and branch offices in the cities of: New Delhi, Calcutta, Bombay, Bangalore, Chandigarh, Jaipur, Lucknow, Bhubanesware, Bhilai, Rourkela, Baroda, Indore, Pune, Cochin, Hydrabad, Madras, Coimbatore, and Visakhapatam.

B. Adjustable Speed Drives (ASD)

Technical Description:
An ASD (or variable-frequency drive) is a motor accessory that enables motorized equipment to be operated over a range of speeds to exactly meet the requirements of a changing load, rather than operating at a single, constant speed. ASDs can be used to replace damper controls, variable inlet vane controls, fluid and eddy drive systems, and mechanical and slip-ring motor resistance controls.

An ASD is a packaged electronic device, and is usually composed of three components:

First Stage	- Solid-state rectifier, which converts input AC power to DC power
Second Stage	- Filter to smooth the electrical waveform
Third Stage	- Inverter used to convert DC to an adjustable frequency AC

ASDs are applied as retrofits on existing motors. The connection to the motor is purely electrical.

Energy Savings:
Electricity savings depend largely on the specifics of the application where ASDs are installed. They are most cost-effective in situations where load on the motor varies and often drops below 65% loading (below which, a constant-speed motor=s efficiency falls rapidly). They are most widely applicable on fan and pump motors providing variable flow. Savings typically range from 20% to 40%, depending on the specific application.

Capital Costs:
Range from 6,200 to 23,000 Rs./hp depending on motor size; the larger the motor, the lower the per horsepower cost. Capital costs are similar to those of ASDs sold in the U.S.

1995/1996 Excise Tax: 10%

Estimated Simple Payback Period:
Estimated payback periods range from less than one year to five years, depending on motor size, operating characteristics, and electricity prices. If we assume that the motor operates 3,000 hours a year and electricity consumption is reduced by 40%, then the payback period ranges from 3 to 20 years. Payback periods tend to be long because the full cost (rather than the incremental cost for replacement EEDs) of the measure must be repaid in savings.

Not included in the payback period calculation are cost savings resulting from extended motor life, reduced energy use resulting from soft-starts, automatic motor protection features, reduced operating noise, improved power factor, and improved process control (and thus product quality control).

Estimated Number of Standard Efficiency Devices Currently in Place:
See the previous section on energy-efficient motors for an estimate of the number of standard-efficiency motors operating in India.

Current Penetration of Efficient Device:
Currently less than 1% of the motors operating in India have ASDs.

Estimated Eligibility:
We estimate that about 10% of the general motor stock is eligible to be retrofitted with ASDs, 25% of the pumps and fans are eligible for ASDs except for pumps in the agriculture sector, which have an estimated ASD eligibility of 1%. These ASD retrofits are anticipated to result in 40% electricity savings.

Technical Energy Savings Potential:

	motors	pumps	fans
Industrial sector			
replacements (1,000 ASDs)	50	88	100
savings (Gwh)	1,000	1,900	1,100
Service sector			
replacements (1,000 ASDs)	-	30	-
savings (Gwh)	-	720	-
Agricultural sector			
replacements (1,000 ASDs)	-	95	-
savings (Gwh)	-	100	-
TOTAL			
replacements (1000 ASDs)	50	213	100
savings (Gwh)	1,000	2,720	1,100

Device Population Forecast:
In 1987, about 200 AC and 1,000 DC adjustable speed drives were sold in India (TERI, 1990). The penetration of ASDs is anticipated to be rather slow primarily because of their high, initial capital cost.

Device Specific Barriers:
ASDs: high costs result in relatively long payback periods. Costs are high, in part, because many of their components are foreign-made and face a 35% customs tax on top of excise taxes.

ASD application sites need to be very carefully chosen to ensure cost effectiveness. They are applicable for motors which operate for most of the year at continually varying speeds or where motor speed control can significantly improve the quality and value of the manufactured good.

#1

Adjustable Speed Drives

Supplier: Crompton Greaves
Machine 3 Division
A-6/2 MIDC
Ahmednagar 414 111
phone: 7372, or 7374 or 7375 or 7507
fax: (0241) 202 8025

Technical Specifications: Model AVS Drive #1000 - 5000

Anticipated Life: over 15 years
Capacity: for 0.5 to 250 hp (0.37 to 200 kW) AC motors
Supply Voltage: 3 phase, 415 V +/- 10%
Frequency: 50 Hz +/- 5%
Power Factor: near unity

Model Number	1000	2000	3000	4000	5000
Motor size (hp):	<10	10-30	30-60	60-125	125-250
Motor size (kW):	<7.5	7.5-22	22-45	45-90	90-185

Energy Savings

Typically 20% to 40% of motor consumption depending on the application.
Typical Simple Payback Period: 3 to 4 years

Estimated Price in Rupees

Model	1000	2000	3000	4000	5000
Motor size (hp):	5	20	50	NIS	NIS
Price:	78,000	210,000	400,000	NIS	NIS
Taxes:	7,800	21,000	40,000		
Installation cost:	1,750	7,000	17,500		
Total cost:	87,550	238,000	507,500		

Availability:

Present Production Level: 100 units/year (in 1994)
Anticipated Future Production Level: 1000 units/year in 1997
Branch and regional offices in the cities of: New Delhi, Calcutta, Bombay, Madras, Jaipur, Jalandhar, Lucknow, Bhubaneshwar, Gauhati, Panta, Ahmedabad, Indore, Nagpur, Baroda, Pune, Bangalore, Secunderabad, Cochin, Coimbator,e and Vijayawada.

Comments:

- Manufactured under technical collaboration with Powertech U.S.A.

#2

Adjustable Speed Drives

Supplier: Kirloskar Electric
Unit IV, Belavadi Industrial Area
Mysore 571 186
phone: 42522 to 25
fax: 0821 42266

Technical Specifications: Model KVR-G5S

Anticipated Life: over 15 years
Capacity: for 2.2 to 22 kW AC motors
Supply Voltage: 3 phase, 415 volts, 50 Hz
Power Factor: NIS
Frequency Resolution: 0.01 Hz
Automatic V/F
Jump frequency control
Jogging operation 1 to 60 Hz
Multi speed step changes: 5 steps maximum

Energy Savings

Typically 20% to 40% of motor consumption depending on the application.
Typical Simple Payback Period: NIS

Estimated Price in Rupees:

Motor size (kW):	2.2	5.5	9.3	15
Price:	NIS	NIS	NIS	NIS

Availability:

Regional offices in the cities of: NIS

Comments:

- Manufactured in collaboration with Fuji Electric Co. Ltd., Japan

#3

Adjustable Speed Drives

Supplier: Kirloskar Electric
Unit IV, Belavadi Industrial Area
Mysore 571 186
phone: 42522 to 25
fax: 0821 42266

Technical Specifications: Model KRENIC 5000
Anticipated Life: over 15 years
Capacity: for 30 to 280 kW AC motors
Supply Voltage: NIS
Power Factor: NIS
Frequency Resolution: NIS

Energy Savings
Typically 20% to 40% of motor consumption depending on the application.
Typical Simple Payback Period: NIS

Estimated Price in Rupees:

Motor size (kW):	30	55	150	250
Price:	NIS	NIS	NIS	NIS

Availability:
Regional offices in the cities of: NIS

Comments:
- Manufactured in collaboration with Fuji Electric Co. Ltd., Japan

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#4

Adjustable Speed Drives

Supplier: Kirloskar Electric
Unit IV, Belavadi Industrial Area
Mysore 571 186
phone: 42522 to 25
fax: 0821 42266

Technical Specifications: Model Digitrak
Anticipated Life: over 15 years
Capacity: NIS
Supply Voltage: 3-phase, 415 volts +/-10%, 50 Hz +/-3%
Power Factor: NIS
DC output: armature voltage 400/440 volts, load current up to 1800 amps DC, field voltage 220 volts or 180 volts typically.

Energy Savings
Typically 20% to 40% of motor consumption depending on the application.

Typical Simple Payback Period: NIS

Estimated Price in Rupees:

Motor size (kW):	2.2	5.5	9.3	15	30	55
Price:	NIS	NIS	NIS	NIS	NIS	NIS

Availability:

Regional offices in the cities of: NIS

Comments:

- Indian designed and manufactured

#5

Adjustable Speed Drives

Supplier: Asea Brown Boveri Limited (ABB)
No. 5 & 6 II Phase Peenya Industrial Estate
Bangalore 560 058
phone: 080-839-5181
fax: 080-839-6537

contact person: Mr. B. Sriram

Technical Specifications: Model ACS 200

Anticipated Life: over 15 years
Capacity: for 0.55 to 4.0 kW A.C. squirrel cage motors
Mains Connection:
Voltage: 1- and 3-phase, 208 to 240 V, and 380 to 480 V +/- 10%
Frequency: 48 to 63 Hz
Motor Connection:
Frequency: 0 to 500 Hz
Switching Frequency: 1.0 to 16.0 Hz

Energy Savings

Typically 20% to 40% of motor consumption depending on the application.
Typical Simple Payback Period: NIS

Estimated Price in Rupees:

Motor size (kW):	2.2
Price:	NIS

Availability:

Regional and branch offices in the cities of: New Delhi, Calcutta, Bombay, Bangalore, Chandigarh, Jaipur, Lucknow, Bhubaneswar, Bhilai, Rourkela, Baroda, Indore, Pune, Cochin, Hydrabad, Madras, Coimbatore, and Visakhapatam.

#6

Adjustable Speed Drives

Supplier: Asea Brown Boveri Limited (ABB)
No. 5 & 6 II Phase Peenya Industrial Estate
Bangalore 560 058
phone: 080-839 5181
fax: 080-839 6537

contact person: Mr. B. Sriram

Technical Specifications: Model number 500
Anticipated Life: over 15 years
Capacity: for 2.2 to 250 kW A.C. squirrel cage motors
Mains Connection:
Voltage: 3-phase, 415 V +/- 10%
Frequency: 48 to 63 Hz
Fundamental Power Factor: Approx. 0.98
Motor Connection:
Frequency: 0 to 500 Hz (up to 60 kVA) and 0 to 150 Hz (above 60 kVA)
Frequency Resolution: .01 Hz
Switching Frequency 1-12 kHz (up to 60 kVA) and 3 kHz (above 60 kVA)

Energy Savings
Typically 20% to 40% of motor consumption depending on the application.
Typical Simple Payback Period: NIS

Estimated Price in Rupees

Motor size (kW):	5.5	9.3	15	30	55
Price:	NIS	NIS	NIS	NIS	NIS

Availability:
Regional and branch offices in the cities of: New Delhi, Calcutta, Bombay, Bangalore, Chandigarh, Jaipur, Lucknow, Bhubanesware, Bhilai, Rourkela, Baroda, Indore, Pune, Cochin, Hydrabad, Madras, Coimbatore, and Visakhapatam.

#7

Adjustable Speed Drives

Supplier: Amtech
E-6, GIDC Electronic Zone
Gandhinagar 382 044
phone: 02712 - 25324, 27294, 27304
fax: 02712 - 24611

Technical Specifications:

Anticipated Life: over 15 years
Capacity: for 1 to >200 hp motors

Energy Savings

Typically 20% to 40% of motor consumption depending on the application.
Typical Simple Payback Period: NIS

Estimated Price in Rupees

for 1 hp drive	37,000
for 200 hp drive	700,000

Availability:

Regional and branch offices in the cities of: NIS

Comments:

Manufactured in technical collaboration with Graseby Controls of the U.S.

C. Motor Rewinding

Technical Description:
Many motor failures are caused by winding failures. With age, overheating, and overvoltage transients, the insulation on motor winding degrades. As the winding's insulation degrades, the performance of the motor declines and ultimately fails. Upon failure, the operator has the choice of replacing the entire motor or replacing the motor's rotor windings. Because of its relatively low cost, rewinding is very common in India.

If rewinding is done improperly, the motor can be damaged and the efficiency of the motor reduced drastically. For example, to remove the windings, motor rotors are commonly baked in an oven. If the oven temperature is not properly controlled, the magnetic properties of the rotor can be altered and the motor efficiency reduced.

In the U.S., rewinding is most common and economical on large, expensive motors. But in India, where labor is cheap, the rewinding of small motors is also very common. In fact, the majority of motor rewinds are done on small motors. Because of the availability of inexpensive labor, rewinding is done largely by hand, rather than using expensive instruments as is the case in the U.S. Thus, the penetration of motor rewinding equipment (e.g., ovens with precise temperature control) is much lower than in the U.S.

Motors operating in India typically have an efficiency of 4% to 13% less than manufacturers' ratings for new motors (TERI, 1988). The larger the motor, the smaller the difference. It is estimated that one-fifth to one-half of the derating results from poorly rewound motors. Even when rewinding is done well, the motor will not be returned to its original off-the-shelf efficiency.

India has a large used motor market. Motors are typically used for much longer than 15 years. They are often used until there is no possible way of repairing them. An Indian motor is typically rewound and repaired until further rewinding/repair is no longer possible. It is estimated that for every new motor sold, 10 motors are rewound (AEC, 1995).

High-quality rewind jobs are rarely done in India, although they are available. A high-quality rewind job has the following characteristics: (1) uses electrical grade copper (99% conductivity) rather than commercial grade copper (95% conductivity), (2) the gauge of winding wire is decreased due to improved and thinner insulation (this also allows the number of windings and thus motor capacity to be increased), (3) F class insulation is used in place of B class insulation, (4) electrical connections are improved.

Energy Savings:
By improving motor rewinding and repair practices, it is estimated that motor efficiency losses could be reduced two to three percentage points (ACEEE, 1991). No field tests have been done in India to compare the motor efficiency impacts of standard- and high-quality motor rewinding.

Capital Costs:
High-quality rewinding typically costs 10% to 15% of the cost of a new, standard-efficiency motor. In India, high-quality motor rewinding costs about 25% more than standard rewinding. Rewinding costs are based on the best, currently available motor rewinding in the city of Ahmedabad (AEC, 1995).

1995/1996 Excise Tax: 10%

Estimated Simple Payback Period:
If we assume that the motor operates 3,000 hours a year, electricity consumption is reduced by 2%, and the cost of power is 2.5 Rs/kWh, then the payback period is about two years.

Estimated Number of Standard-Efficiency Devices Currently in Place:
See energy-efficient motors for an estimate of the number of standard-efficiency motors operating in India.

Current Penetration of Efficient Devices:
It is estimated that the best rewinding practices are used for less than 5% of motors rewound.

Estimated Eligibility:
We estimate that about 95% of the Indian motor rewinding shops and motor rewind jobs are eligible for rewinding improvements. An estimated 25% of the current motor stock will be rewound in the next 15 years.

Technical Energy Savings Potential:

	motors	pumps	air & refrigeration compressors	fans
Industrial sector				
rewinds (1000 jobs)	680	88	29	99
savings (GWh)	350	90	45	50
Service sector				
rewinds (1000 jobs)	-	120	-	-
savings (GWh)	-	35	-	-
Agricultural sector				
rewinds (1000 jobs)	-	2400	-	-
savings (GWh)	-	260	-	-
TOTAL				
rewinds (1000 jobs)	680	2608	29	99
savings (GWh)	350	385	45	50

Device Population Forecast:
As the price of electricity continues to increase, there will be escalating pressure on rewind shops to reduce the losses attributed to rewinding.

Device Specific Barriers:
Cost minimization in the Indian small-scale business sector is a high priority. The small-scale sector is an important customer of rewind shops. These businesses tend to choose the least, first cost measure rather than the option having the lowest life-cycle cost.

Currently, inexpensive labor and repair materials are used rather than more expensive materials. This cost structure allows small motors to be rewound. If a rewind shop shifts to using expensive equipments and high cost materials, then rewind jobs, primarily of smaller motors, would be less affordable to the customer. As a possible result, the rewind shop could lose some customers and market share.

It seems that most motor rewind shop customers are unaware or not convinced of the benefits of high-quality motor rewinding.

In India, it is common practice to rewind motors whenever possible without considering the purchase of new motors. Yet, in many cases it may be more cost-effective to replace motors with energy-efficient motors. This habit will take time to change.

#1
High Quality Motor Rewinding
Supplier: Varies

Example: Siddhartha Electric Works
74, Banner Industrial Estate, Opp.
Soma Textile, Rekhiel Road,
Ahmedabad, India 380 023
Phone: 274 2057

contact person: Siddhartha Patel

Technical Description:
Highest quality motor rewinding available in Ahmedabad India. Includes the use of Class F insulation and smaller gage winding wire. Motor rotor and winding effectiveness is not detrimentally affected by rewinding process.

Energy Consumption:
Savings: Estimated 2%
Typical Simple Payback Period: less than 2 years

Estimated Price in Rupees (price quote of 5/8/95):

Motor Size (kW)	2.2	5.5	9.3	15	30	55

1440 to 2880 RPM motors Total Cost:	1,037	1,640	2,730	3,773	7,153	NIS
720 to 960 RPM motors Total Cost:	1,114	1,763	2,936	4,055	7,689	NIS

D. Cogged V-Belts

Technical Description:
About 30% of all motor (commonly fan motor) applications use belt drives to transmit motor energy to the task. Standard V-belts are the most common belt drive system. Standard V-belts operate at an efficiency of 90% to 96% if well maintained. Typically, three to five belts are used for each drive. An average drive=s standard V-belts last about a year and operate for about half of the year in a badly worn and inefficient state. Often drives are operated without their full complement of belts, resulting in increased losses.

V-belts can be replaced by cogged V-belts as an energy-efficiency and cost-savings measure. Cogged V-belts can be used at virtually all standard V-belt applications without any drive modifications. Cogged V-belts have minimal stretch, reducing the need to maintain proper tension on belts. Also, because of their improved durability and efficiency, the number of belts can be reduced when designing new belt drive systems.

Energy Savings:
A cogged V-belt has an efficiency one to three percentage points better than a standard v-belt. Energy savings result from reduced slip and frictional heat production. Cogged belts have a life of three times that of standard V-belts.

Capital Costs:
Cogged v-belt capital costs are typically two to two and one-half times greater than standard v-belts.

1995/1996 Excise Tax: 10%

Estimated Simple Payback Period:
The estimated simple payback period is typically less than one year.

Estimated Number of Standard-Efficiency Devices:
See energy-efficient motors for the number of standard-efficiency motors operating in India. Each motor with a belt drive uses two to five standard, or cogged, V-belts.

Current Penetration of Efficient Device:
The current penetration is estimated at less than 10% of the belt drives operating in India.

Estimated Eligibility:
We estimate that about 85% of the Indian motor belt drive applications are eligible for cogged V-belts upgrades.

Technical Energy Savings Potential:
Cogged V-belts could potentially save 110 million kWh at general purpose motors and 20 million kWh at fans in the industrial sector.

Device Population Forecast:
There are no serious barriers limiting the sales of cogged V-belts. Once their benefits are understood by motor drive technicians, energy professionals, and plant management, they should rapidly capture a large portion of the V-belt market.

Device Specific Barriers:
None identified

Assumptions used for Incremental Cost and Payback Calculations:

Savings estimates are based on: an 85% efficient 15 kW motor operating at 3/4 full load for 3,000 hours/year, using three belts and a power tariff of 2.5 Rupees/kWh. Drive efficiency is estimated to improve by two percentage points.

Cost (taxes not included) of standard B section V-belts: 90 Rs. for 980 mm; 122 Rs. for 1480 mm; and 151 Rs. for 1990 mm (prices from Fenner Limited). Installation and maintenance cost assumed to be equal for the standard and cogged V-belts. Life of the standard V-belt is one year. Life of the cogged V-belt is three years.

#1

Cogged V-Belts

Supplier: Fenner India LTD
9-1-87 Sarojini Devi Road
Secunderabad, India 500 003
phone: 822-299 or 825-727

Technical Description:

Cogged V-belts have Alength stable@ polyester cords coated with a special adhesive and compound base. Belt stretch is minimal - reducing the need for maintenance. The number of belts used per application can be reduced up to 30%. Their anticipated life is three times that of ordinary V-belts

Technical Specifications:

Available in a number of cross sections and lengths.

Energy Consumption:

Savings: depend on size of motor(s), the number and length of belts, the annual hours of motor operation, and motor loading.
Typical Simple Payback Period: less than one year
Life: 1.5 to 3 years

Estimated Price:

pitch length (mm):	980	1480	1990
Cross Section 13 X 8 mm			
Price (Rupees):	133	169	209
Cross Section 17 X 11 mm			
Price (Rupees)	161	220	270

Energy Savings: for one B Section cogged V-belt

Savings kWh/year:	1150	1150	1150
Savings Rupees/year:	2875	2875	2875
Payback years:	0.07	0.1	0.12

Estimated Price in Rupees: for three B section cogged V-belt

Incremental Price (Rupees):	213	294	357

Availability:

Indian States having area/branch offices: Ahmedabad, Bangalore, Bombay, Calcutta, Delhi, Indore, Gaper, Kanpur, Ludhiana, Madras, Madurai, and Secunderabad

E. Motor Soft Start Controllers

Technical Description:
The starting current for a typical industrial motor can be as much as five to seven times its full load current. Motor voltage soft-start controllers moderate power surges during starting and motor acceleration by using resistor or reactors, thereby reducing electricity consumption. A small fraction (less than 2%) of the motors sold in the U.S. come with soft-starter controls.

Motors starting under high loads are not candidates for soft-starting. Motor soft-start controllers are applied as retrofits on existing motors; the connection to the motor is purely electrical.

Energy Savings:
Electricity savings depend largely on the specifics of the application where soft-start controllers are installed. Savings typically range from 2% to 5%, depending on the application.

Capital Costs:
In the U.S., soft-starters cost about 340 Rupees per horsepower (or 460 Rupees/kW) installed.

1995/1996 Excise Tax: 10%

Estimated Simple Payback Period:
The estimated payback period is approximately two years depending on motor size, electricity tariffs, and motor operating characteristics.

Estimated Number of Standard-Efficiency Devices Currently in Place:
See energy-efficient motors for an estimate of the number of standard-efficiency motors operating in India.

Current Penetration of Efficient Device:
Current penetration is less than 1% of the eligible motors operating in India.

Estimated Eligibility:
We estimate that about 5% of the Indian motor stock is eligible to be retrofitted with soft-starting controllers.

Technical Energy Savings Potential:
By installing 140,000 soft-start controllers on general-purpose motors in the industrial sector, approximately 55 GWh could be saved annually.

Device Population Forecast:
The demand for soft-start controllers should grow as their benefits are better understood and real electricity prices continue to increase.

Device-Specific Barriers:

Motors suitable for motor soft-start control must be specified individually. The specifying engineer must understand both the motors operating parameters and soft-starter controllers to properly gauge the suitability and cost-effectiveness of soft-start controllers.

Generally all soft-start controllers are imported or made of imported components and, thus, face import duties of 20% to 40%.

#1

Motor Soft-Starter Controllers

Supplier: Crompton Greaves
Electronics Technology Division
71/72 MIDC
Satpur, Nashik 422 007
phone: (0253) 351-069
fax: (0253) 351-492

Technical Description:

Three sets of thyristors pairs vary the voltage applied to the motor by electronic control. During motor acceleration the device gradually increases motor voltage while limiting motor current to a reference current ramp limit. The device reduces starting current surges, controls starting acceleration, reduces energy consumption on partially loaded motors, and provides electronic motor protection.

Technical Specifications: Electronic Reduced-Voltage Soft-Starter, Model: ESI
Anticipated Life: 15 years

Energy Consumption:

Savings: depends on size of motor(s), the motor power saved, and the annual hours that the motor is operated at partial load.
Typical Simple Payback Period: 2 years

Estimated Price in Rupees:

Price: NIS

Availability:

Present Production Level: 202 units/year (in 1994)
Anticipated Future Production Level: 300 units/year in 1997.
Indian States not having sales outlets: North Eastern States (North and east of West Bengal)
Regional offices in the cities of: New Delhi, Calcutta, Bombay, and Madras.

Comments:

- Manufactured under collaboration with Westinghouse USA.

Efficient Electric End-Use Devices:
The Indian Market

Energy Efficient Lamps and Ballasts

January 1996

prepared by
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for
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under
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5.2 Lamps and Ballasts

A. Compact Fluorescent Lamps (CFLs)

Technical Description:
New CFLs use rare earth phosphors to produce warm colors, rather than the colder colors emitted by older generation CFLs. They are composed of multiple, short fluorescent tubes in order to keep their dimensions similar to that of a standard incandescent bulb. CFLs have two components: the fluorescent tube and an electronic ballast[11].

CFLs are able to deliver the same light intensity (or lumen output) as a standard incandescent lamp while using a fraction of the wattage. For example, a 15-watt compact fluorescent produces as much light as a 60-watt incandescent bulb. Compact fluorescents are able to fit into standard incandescent outlets, although they may not fit into the incandescent luminaries. CFLs are screwed directly into an incandescent base fixture without any adaptations. CFLs operate 10 to 13 times longer than incandescent lamps.

Energy Savings:
Electricity savings depend largely on the specifics of the application where CFLs are installed. Savings typically range from 60% to 75% per unit of light output depending on wattage of the incandescent lamp and the CFL replacement.

Capital Costs:
CFL=s capital cost is typically 15 times that of an incandescent lamp; but because they last 10 to 13 times as long as standard incandescent lamps and use much less power, their life-cycle cost is much less than that of operating and replacing 15 incandescent lamps.

1995/1996 Excise Tax: 10%

Estimated Simple Payback Period:
Estimated payback periods are typically between 0.1 and 1 year depending on the hours they are used annually and the price of power.

Estimated Number of Standard-Efficiency Devices Currently in Place:
Incandescent Bulbs

Sector	Industrial	Residential	Commercial	Service	Agriculture	TOTAL
	1,300,000	150,000,000	5,900,000	1,500,000	9,700,000	168,400,000

[11] The ballast typically accounts for approximately 15% of the lamp=s electricity consumption.

Current Penetration of Efficient Device:
The current penetration of CFLs is less than 1% of the incandescent fixtures operating in India.

Estimated Eligibility:
We estimate that about 5% to 20% of the Indian incandescent lamp stock is eligible to be replaced with CFLs, depending on the economic sector. CFLs do not fit into all incandescent fixtures, thus limiting their eligibility without significantly increasing replacement cost.

Technical Energy Savings Potential:

Sector	Industrial	Residential	Commercial	Service	Agriculture	TOTAL
replacements	260,000	7,600,000	1,200,000	300,000	970,000	10,330,000
savings (GWh)	65	500	190	90	80	925

Device Population Forecast:
The market forecast for CFLs depends largely on their ability to overcome barriers. In the U.S., penetration is rather low; their application has been far more widespread in northern Europe.

The 1995 market for incandescent bulb replacements (this includes CFLs and tube fluorescent lamps) is estimated to have a value of $US 150,000,000.

Device-Specific Barriers:
Compact fluorescent bulbs have met with resistance in the U.S. because of their high capital costs and the colder tint light they emit. Compact fluorescents are often removed by the end-user before they reach the end of their useful life because the end-user does not like the color spectrum of light they emit. This may not be a problem in India because tube fluorescent lighting is very common and accepted.

Their initial high capital cost is the major barrier to CFLs. Indian customers are very price-sensitive, particularly in the residential and commercial sectors. For the average residential customer, the cost of a single CFL equals a large portion of his weekly salary.

CFLs will not fit into most Indian incandescent luminaires. If CFLs are to be widely installed, the added cost of replacing luminaires will be required, thereby further increasing their initial capital costs.

Comments:
In 1991, no CFLs were being made in India, and imported CFLs were taxed at a rate as high as 350%. However, there are currently six Indian firms manufacturing CFLs domestically.

Heat production by lights is an important consideration for Indians. For this reason fluorescent lamps are generally preferred to incandescent lamps. Thus, Indians have been living with a larger fraction of fluorescent lighting than Americans.

Assumptions used for Incremental Cost and Payback Calculations:
Based on 3,000 hours of use per year. Electricity cost of 2.5 Rupees/kWh is used for all calculations. Based on the incremental cost which was calculated over the life the CFL and the annual electricity savings.

Determined over the life of the CFL using the following assumptions: incandescent lamps have a life of 1,000 hours, a 25- watt incandescent lamp costs 7 Rupees, a 40-watt costs 9 Rupees, a 60-watt costs 10 Rupees, and a 75-watt costs 12 Rupees. Installation labor costs are not included in the payback calculation.

#1
Compact Fluorescent Lamps
Supplier: Autopal Industries Limited
D-469 Road No. 9A, V.K.I. Area
Gaper India 302013
phone: 0141-330-426 or 331-394 or 331-634
fax: 0141-382-828 or 330-349

contact person: Mr. C.H. Parashar

Technical Specifications:
Anticipated Life: over 8,000 hours
Voltage: 180 to 290

CFL Rating	Lumens	Current (mA)	Length (mm)	Incandescent Lamp Equivalent (W)
5 W	250	180	105	25
7 W	410	175	135	40
9 W	600	170	165	60
11 W	900	160	235	75

Energy Consumption	5W	7W	9W	11W
Savings kWh /year:		60	99	153 192
Savings Rupees/yr:	150	248	383	480
Payback years:	0.3	0.2	0.1	0.1

Estimated Price in Rupees (6/2/95)	5W	7W	9W	11W
Price:	107	112	120	125
Tax:		Included in Price		
Incremental Price:	51	40	40	29

Availability:
Indian States not having sales outlets: Arunachal Pradesh, Mizoram, Manipur, Tripura, Pondicherry, and Sikkim.

#2

Compact Fluorescent Lamps

Supplier: Philips India
Lighting Design and Engineering Center
P-65, Taratolla Road
Calcutta 700-088
phone: 714-245
fax: 033-714-247

Technical Specifications:

Anticipated Life: 8,000 hours
Voltage: 180 to 290

Model: SL Prismatic

Rating	Lumens	Lumen/ Watt	Incandescent Lamp Equivalent (W)
13 W	575	44	60
18 W	850	47	75
25 W	1100	44	100

Model: SL Comfort

Rating	Lumens	Lumen/ Watt	Incandescent Lamp Equivalent (W)
13 W	550	42	60
18 W	800	45	75
25 W	1050	42	100

Energy Consumption	13W	18W	23W
Savings kWh /year:	141	211	225
Savings Rupees/yr:	352	527	562
Payback (years):	1	0.6	0.5

Price in rupees (list prices of June 1, 1994)

	13W	18W	25W
Price:	399	399	399
Tax:	included in price		
Incremental Price:	369	303	279

Availability:

Regional offices in the cities of: Calcutta, New Delhi, Bombay, and Madras.

#3

Compact Fluorescent Lamps

Supplier: Osram India PVT. LTD.
1/95 Market Road
(Bhai Veer Singh Lane)
New Delhi 110001
phone: 011-334-8569 or 334-8570
fax: 01-334-8563

contact person: Mr. Sthalekar, National Sales and Marketing Manager

Technical Specifications:

Anticipated Life: 10,000 hours

Model:	Dulux D			
Watts:	10	13	18	26
Lumen	600	900	1200	1800
Incand. Equiv:	60	75	100	150
Lumen/watt	60	69	67	69

Model:	Dulux T		
Watts:	18	26	32
Lumen	1200	1800	2400
Incand. Equiv:	100	150	200
Lumen/watt	66	69	75

Model:	Dulux EL				
Watts:	5	7	11	15	20
Lumen	200	400	600	900	1200
Incand. Equiv:	25	40	60	75	100
Lumen/watt	40	57	54	60	60

Model:	Dulux S			
Watts:	5	7	9	11
Lumen	250	400	600	900
Incand. Equiv:	25	40	60	75
Lumen/watt	50	57	67	81

Energy Consumption Model Dulux D

Watts	10	13	18	26
Savings kWh/year:	150	186	246	372
Savings Rupee/year:	375	465	615	930
Payback years:				

Estimated Price in Rupees Model Dulux D

Dulux D (watts)	10	13	18	26
Price:	NIS	NIS	NIS	NIS
Tax:				
Incremental Price:				

Availability:

Indian States not having sales outlets: distributor/dealer network is currently being developed

Comments:

Until mid-1995, when their domestic manufacturing facility will begin operating, Osram will import CFLs.
A wholly owned subsidiary of OSRAM GmbH. Germany

#4

Compact Fluorescent Lamps

Supplier: Crompton Greaves: Lighting Division
Dr. E Moses Road
Worli Bombay 400 018
phone: 495-1983 or 495-1973 or 495-1809
fax: 022-495-0485

contact person: Mr. Vilas Prabhu

Technical Specifications:

Anticipated Life: over 8,000 hours

Rating	Lumens	Current (mA)	Length (mm)	Incandescent Lamp Equivalent (W)
5 W	250	180	108	25
7 W	400	175	138	40
9 W	600	170	168	60
11 W	900	160	238	75

Energy Consumption	5W	7W		9W	11W	
Savings kWh /year:		60	99		153	192
Savings Rupees/year:	150	248		383	480	
Payback years:	0.3	0.2		0.1	0.1	

Estimated Price in Rupees (list prices of ?)

	5W	7W	9W	11W
Price:	107	112	120	125
Tax:		taxes included in price		
Incremental Price:	51	40	40	29

Availability:

Regional offices located in the cities of: New Delhi, Gaper, Jalandhar, Lucknow, Chandigarh, Calcutta, Guwahati, Patna, Bhubaneshwar, Bombay, Ahmedabad, Indore, Nagpur, Baroda, Pune, Madras, Bangalore, Cochin, Secunderabad, Coimatore, and Vijaywada

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B. Efficient Tube Fluorescent Lamps

Technical Description:
Fluorescent tube lamps contain phosphors which are excited by the flow of an electrical current and emit light. By using different types and combinations of phosphors, both the lamp=s efficiency and color-rendering properties are affected. In the mid-1970's, fluorescent tube efficiencies were improved by using krypton rather than argon for the inert gas and by disconnecting the cathode after the arc was struck. U.S. made efficient 4-foot tubes typically operating at an efficiency of 90 lumen/watt, while standard-efficiency 4-foot tubes emit about 80 lumen/watt. Lumen flux, as with most lamps, decreases over the life of the lamp.

Most of the standard-efficiency tube fluorescent lamps can be replaced by efficient fluorescent tube lamps. Also in many cases incandescent lamps can be replaced by tube fluorescent fixtures (efficient lamps and electronic ballasts).

Energy Savings:
Indian high efficiency 4 foot tube fluorescent lamps use 36 watts compared to the 40 watts of the standard efficiency 4 foot lamps. The lighting level remains constant with a 12.5% reduction in electricity consumption. Savings of 10% to 13% are virtually guaranteed for all applications.
In India these energy savings gains were made by going to a smaller diameter tube (this can only be done with 220 - 240 volt electrical service) and using tri-phosphors.

Conversion of incandescent lighting to efficient tube fluorescent lamps results in about 20% to 25% savings.

Capital Costs:
Currently, efficient fluorescent tube lamps cost about one-and-a-half times a standard-efficiency tube lamp.

1995/1996 Excise Tax: 10%

Estimated Simple Payback Period:
The typical payback is about two years, depending on the application and the price of electricity.

Estimated Number of Standard-Efficiency Devices Currently in Place:
Standard-Efficiency, 4' Fluorescent Tube Lamps:

Sector	Industrial	Residential	Commercial	Service	Agriculture	TOTAL
	26,000,000	10,000,000	36,000,000	8,000,000	12,000,000	92,000,000

Current Penetration of Efficient Device:
The current penetration of efficient tube fluorescent lamps is less than 10% of the fluorescent tube lamps operating in India.

Estimated Eligibility:
We estimate that about 90% of the Indian tube fluorescent lamp stock is eligible to be replaced with efficient tube fluorescent lamps.

Technical Energy Savings Potential:

Sector	Industrial	Residential	Commercial	Service	Agriculture	TOTAL
conversion from incandescent lamps to efficient tube fluorescent fixtures						
tube replacements	1,920,000	76,000	1,670,000	460,000	1,500,000	5,626,000
ballast replacements	960,000	38,000	880,000	230,000	725,000	2,823,000
savings (GWh)	65	440	92	190	120	907
conversion from standard to high efficiency fluorescent tubes						
tube replacements	5,200,000	9,800,000	34,000,000	6,500,000	9,900,000	65,400,000
savings (GWh)	260	78	170	450	160	1,118

Device Population Forecast:
A moderate rate of penetration of efficient tube lamps is anticipated.

They will be most cost-effective at new construction sites where they are used in combination with electronic ballasts. In this situation, lumen output are greater for the efficient fluorescent fixture (i.e., efficient tube lights and electronic ballasts) than for the standard fluorescent fixtures, allowing for a decrease in the number of fixtures while maintaining lumen output.

Device-Specific Barriers:
None identified

Comments:
In India, 18 medium and large enterprises produce 53 million fluorescent tube lamps annually.

Other firms producing efficient tube lights include Mysore, Osler, and Sonya.

Lamp lumen output decreases with age at about the same rate for both efficient and standard tube lamps (6% to 12% lumen reduction after 2,000 hours of use) (EMC, 1993).

Indian consumers prefer fluorescent lamps to incandescent lamps because they produce less heat. Thus, they are much more common in residential and commercial applications than in the U.S.

Most fluorescent residential and commercial sector fixtures hold a single, 4-foot tube, while most industrial fixtures hold two, 4-foot tubes.

Assumptions used for Incremental Cost and Payback Calculations:
Determined based on 3,000 hours of use per year. A electricity cost of 2.5 Rupees/kWh is use for all calculations. Standard efficiency lamps are of 20 and 40 watts.

Standard efficiency 20 W and 40 W tube fluorescent lamp costs 43 and 44 Rupees, respectively.

#1

Efficient Tube Fluorescent Lamps

Supplier: Philips India
Lighting Design and Engineering Center
P-65, Taratolla Road
Calcutta 700-088
phone: 714-245
fax: 033-714-247

Technical Specifications, Model: Trulite

Anticipated Life: 20,000 hours

Watts:	18	36
Lumen output:	1300	3250
Length (mm):	604	1213

Energy Consumption:

Savings kWh/year:	6	12
Savings Rupees/year:	15	30
Payback years:		2

Estimated Price in Rupees (list prices of 1/06/94) :

Price:	NIS	100
Taxes:		included in price
Incremental Price :		60

Availability:

Regional offices in the cities of: Calcutta, New Delhi, Bombay, and Madras.

Comments:

Concurrent with tube replacement is an approximate 15% increase in lumen output (this is not considered in the payback calculation).

Because of their increased lumen output and thus reduced fixture requirements, efficient fluorescent tube and electronic ballasted fixtures are most cost-effective for new construction rather than retrofit applications.

Made by Philips in India

#2

Efficient Tube Fluorescent Lamps

Supplier: Crompton Greaves
Lighting Division
Dr. E. Moses Road, Worli
Bombay 400 018
phone: 495 1983, 495 1973, 495 0681, 495 1809
fax: 022 495 0485

contact person: Mr. Vilas Prabhu

Technical Specifications, Model: MCF/U cool day

Anticipated Life: 20,000 hours

Watts:	36
Lumen flux:	2450
Color temperature (K)	6500
Length (mm):	1213

Energy Consumption:

Savings kWh/year:	12
Savings Rupees/year:	30
Payback years:	

Estimated Price in Rupees:

Price:	NIS
Taxes:	
Incremental Price :	

Availability:

Regional offices located in the cities of: New Delhi, Gaper, Jalandhar, Lucknow, Chandigarh, Calcutta, Guwahati, Patna, Bhubaneshwar, Bombay, Ahmedabad, Indore, Nagpur, Baroda, Pune, Madras, Bangalore, Cochin, Secunderabad, Coimatore, and Vijaywada.

C. Electronic Tube Fluorescent Ballasts

Technical Description:
Electronic ballasts are used on tube fluorescent lamps to provide suitable starting voltage and for limiting current flow once the tube lamp is operating. Electronic ballasts convert the input current to a high frequency 20,000 Hz (standard magnetic ballasts operate at 60 Hz) using electronic circuits. The increased frequency of electronic ballasts improves efficiency of the fluorescent tube lamps (i.e., it increases the lamp=s lumen output), and the ballasts have reduced internal losses.

Energy Savings:
It is estimated that electronic ballasts for fluorescent fixtures consume about 30% of the energy consumed by typical standard-efficiency magnetic ballasts, while increasing the lumen output of the fluorescent lamps.

In the U.S. under ideal conditions, fluorescent lighting systems with electronic ballasts can actually draw less wattage than the rated power of the fluorescent tubes alone. For example, a two, 40-watt tube fixture with a magnetic ballast draws 96 watts, while the same fixture with an electronic ballast draws 78 watts (National Lighting Product Information Program, 1991). This A ballast factor@ will affect (usually increase) the lumen output of the lamps, so comparisons between ballasts should be made under similar conditions.

Some ballasts made in India result in similar savings, but savings tend to be highly variable. Because of the relatively poor quality of Indian made ballasts, an estimated 30% ballast savings is used as a conservative savings estimate here.

Capital Costs:
Electronic ballast cost approximately four times as much as standard efficiency magnetic ballasts.

1995/1996 Excise Tax: 10%

Estimated Simple Payback Period:
Estimated payback periods range from two to six years, depending on the specifics of the application.

Estimated Number of Standard Efficiency Devices Currently in Place:
Standard-Efficiency Magnetic Ballasts:

Sector	Industrial	Residential	Commercial	Service	Agriculture	TOTAL
	13,000,000	5,200,000	18,000,000	4,100,000	6,200,000	46,500,000

Current Penetration of Efficient Device:
The current penetration of electronic ballasts is estimated to be less than 10% of the fluorescent fixtures operating in India.

Estimated Eligibility:
We estimate that about 90% of the Indian fluorescent fixture stock is eligible to be retrofitted with electronic ballasts.

Technical Energy Savings Potential:

Sector	Industrial	Residential	Commercial	Service	Agriculture	TOTAL
replacements	10,000,000	4,100,000	14,000,000	3,200,000	4,900,000	36,200,000
savings (GWh)	1,200	170	950	420	400	3,140

Device Population Forecast:
If electronic ballast quality, reliability and customer perception problems can be resolved, their steady penetration into the Indian market is anticipated.

Device-Specific Barriers:
The first ballasts that were sold in India were of relatively poor quality and reliability. They did not meet the expectations of customers. In some cases, their life was one-tenth of that promised by manufacturers, and there were no electricity savings. Thus, electronic ballasts have a rather poor reputation among energy professionals.

Some energy professionals feel that the poor quality of supplied power (e.g., surges, spikes, voltage and frequency problems, brownouts, etc.) significantly reduces the life of electronic ballasts.

Since experiencing these initial problems, the Indian customer has been hesitant to purchase electronic ballasts.

Electronic ballasts that are able to withstand the poor power quality are built more robustly and are thus less efficient than those used in developed countries.

Comments:
There is a need for a well-recognized and respected organization to test electronic ballast life, efficiency, and reliability under the difficult Indian power supply conditions.

In India, it is common for each tube lamp to have its own ballast. Most ballasts available in India are designed to serve one 4' tube fluorescent lamp.

Vapor pressure impregnated technology (VPIT) ballasts are also available in India. These ballasts are of intermediate efficiency and price, between the copper and electronic ballasts.

Assumptions Used for Incremental Cost and Payback Calculations:
Determined based on 3,000 hours of use per year, copper ballast energy losses of 12W and electronic ballast losses of 2W for single, 40W tube fixture, and copper ballast losses of 24 W and electric ballast losses of 3W for a double, 40W tube fixture. Price of power estimated at 2.5 Rupees./kWh. Improvements in lumen output are not considered for payback period calculations.

Standard copper ballasts are estimated to cost 85 Rs. for single 40W tube fixture and 170 Rs. for double 40W tube fixture.

#1
Electronic Tube Fluorescent Ballasts
Supplier: Philips India
Lighting Design and Engineering Center
P-65, Taratolla Road
Calcutta 700-088
phone: 714-245
fax: 033-714-247

Technical Specifications: Model: MES 232 S14
Anticipated Life: 15 years
Ballast Power Losses: less than 4 Watts
Nominal Power Factor: better than 0.96
Operating Voltage: 180 to 270 Volts AC, 50 Hz

Energy Consumption

fixture type:	two 40 or 36 watt tubes	
Savings kWh/year:	60	
Savings Rupees/year:	150	
Payback years:	4.5	

Estimated Price in Rupees

Price:	850	
Taxes:		85
Incremental Price:		680

Availability:
Regional offices in the cities of: Calcutta, New Delhi, Bombay, and Madras.

Comments:
Philips India offers a 5-year warrantee on their ballasts
Made by Philips in India

#2

Electronic Tube Fluorescent Ballasts

Supplier: Crompton Greaves
Lighting Division
Dr. E. Moses Road, Worli
Bombay 400 018
phone: 495 1983, 495 1973, 495 0681, 495 1809
fax: 022 495 0485

contact person: Mr. Vilas Prabhu

Technical Specifications: Model: EnSave High Frequency Electronic Ballast
Anticipated Life: 15 years
Ballast Power Losses: less than 4 Watts
Nominal Power Factor: for LPF (low power factor) version >0.65, for HPF (high power factor) version > 0.9
Operating Voltage: 100 to 300 Volts AC, 50 Hz

Energy Consumption

fixture type:	one 40 or 36 watt tube
Savings kWh/year:	30
Savings Rupees/year:	75
Payback years:	5.5

Estimated Price in Rupees

Price:	495	
Taxes:		50
Incremental Price:		410

Availability:

Regional offices located in the cities of: New Delhi, Gaper, Jalandhar, Lucknow, Chandigarh, Calcutta, Guwahati, Patna, Bhubaneshwar, Bombay, Ahmedabad, Indore, Nagpur, Baroda, Pune, Madras, Bangalore, Cochin, Secunderabad, Coimator,e and Vijaywada.

Comments:

Claims include: no stroboscopic effect, no noise or hum, 40% less heat production when compared to a magnetic ballast, slower lumen depreciation of lamp, and 30% to 50% longer lamp life.

#3

Electronic Tube Fluorescent Ballasts

Supplier: BRB Electronics
11-11/A Samruddhi Shopping Center
Kandivali Village
Dhanukar Wadi
Kandivali (W)
Bombay 400 067

contact person: Mr. Harish Ranawat

Technical Specifications:

Anticipated Life: 15 years
Ballast Power Losses: less than 4 Watts
Nominal Power Factor: > 0.9

Energy Consumption

fixture type:	one 40 or 36 watt tube	two 40 or 36 watt tubes
Savings kWh/year:	30	60
Savings Rupees/year:	75	150
Payback years:	5.9	3.4

Estimated Price in Rupees

Price:	525		680	
Taxes:		53		68
Incremental Price:		440		510

Availability:

NIS

#4

Electronic Tube Fluorescent Ballasts

Supplier: Semitroniks
17 Ard: ana Industrial Estate
Rakhial Road,
Ahmedabad 380 023

phone: 843 822 or 841 011 or 844 609
fax: (079) 841 793

contact person: Mr. H.D. Shah, Director

Technical Specifications:

Anticipated Life: 7,500 hours
Ballast Power Losses: 2 to 3 Watts
Power Factor: 0.9 to 0.95
Operating Voltage: 180 to 270 Volts AC

Energy Consumption

fixture type:	single 40 watt tube	double 40 watt tube
Savings kWh/year:	30	NIS
Savings Rs/year:	75	
Payback years	3.4	

Estimated Price Rupees

Price:	340		NIS
Taxes:			
Incremental Price:		255	

Availability:

Offices in: Ahmedabad, Bombay, Surat and Gandhinagar

Comments:

Carries a two year guarantee.

#5

Electronic Tube Fluorescent Ballasts

Supplier: Opal Electronics/Electrostreaks
No. 47A Sethu Road,
Peravurani, Tanjore Dist.,
Tamil Nadu, India

phone: (04373) 32518
fax: 22 838 5855

contact person: Mr. Madhu Parek

Technical Specifications: Model ES 40

Anticipated Life: 25,000 hours
Fixture Power Consumption: 38 to 37 Watts
Ballast Power Losses: 2 to 3 Watts
Voltage Range: 100 to 300 Volts
Current: 130 mA
Power Factor: >0.9

Energy Consumption

fixture type:	single 40 watt tube	double 40 watt tube
Savings kWh/year:	30	63
Savings Rupees/year:	75	158
Payback years	3.1	3.1

Estimated Price in Rupees

Price:	320	660
Taxes:	included in price	included in price
Incremental Price:	235	490

Availability:

Present Production Level: 50,000 units/year (in 1994)
Anticipated Future Production Level: 100,000 units/year in 1995/96
Indian States not having sales outlets: Western zones and Tamil Nadu

D. Metal Halide Lamps

Technical Description:
Metal halide lamps consist of a high-pressure discharge (sometimes in a mercury vapor) with metal additives operating in a quartz arc tube. Most lamps have an outer bulb which has a fluorescent coating. The fluorescent coating increases light output and improves color rendering. Metal halide lamps typically provide very good to excellent color rendition, making them suitable for almost all indoor and outdoor industrial, commercial, and service sector applications. Their output ranges from 65 to 85 lumen/watt for a 175-watt lamp.

Metal halide lamps most commonly replace mercury vapor lamps (which have outputs between 25 to 40 lumens/watt) where high color rendering is important. Normally one metal halide lamp will replace two mercury vapor lamps. In the U.S. some metal halide lamps are designed to operate on mercury ballasts and fixtures, thereby reducing replacement costs significantly. In the U.S., metal halide lamps have a life of about 10,000 hours, while mercury vapor lamps function for approximately 16,000 hours

Energy Savings:
The conversion results in a savings of approximately 50%.

Capital Costs:
A new fixture costs between 1,000 and 2,000 Rupees, while the new bulb costs 1,500 to 2,000 Rupees, depending on its wattage (or about three times as much as a mercury vapor lamp).

1995/1996 Excise Tax: 10%

Estimated Simple Payback Period:
The estimated payback period is less than two years, based on the installed capital cost of the lamp and fixture only (i.e., labor is not included).

Estimated Number of Standard-Efficiency Devices Currently in Place:
Mercury Vapor Lamps

Sector	Industrial	Commercial	Service	TOTAL
	2,500,000	250,000	530,000	3,280,000

Current Penetration of Efficient Device:
The estimated penetration of metal halide lamps is less than 2% of the lamps operating in India.

Estimated Eligibility:

We estimate that about 25% of the Indian mercury vapor lamp stock is eligible to be retrofitted with metal halide lamps.

Technical Energy Savings Potential:

Sector	Industrial	Commercial	Service	TOTAL
replacements	640,000	62,000	130,000	850,000
savings (GWh)	140	8	33	181

Device Population Forecast:

Metal halide lamps are relatively new to Indian markets. Metal halide lamping is most cost effective during new construction (pay back periods will be less than half a year when compared to mercury vapor lighting systems). This is because of the costly re-fixturing that is required when metal halide lighting systems replace mercury vapor systems.

Demand for metal halide lamps is anticipated to grow rather slowly. Significant portions of the metal halide lamps sales would be to new construction.

Device-Specific Barriers:

For retrofit situations the cost (materials and labor) required for refixturing is the most significant barrier.

Assumptions Used for Incremental Cost and Payback Calculations:

Determined based on 3,000 hours of use each year. Electricity prices of 2.5 Rupees/kWh is used for all calculations. The metal halide lamps replace two mercury vapor lamps of 250 and 400 watts each

2.7 metal halide lamps (with a life of 6,000 hours) are needed to replace each mercury vapor lamp over its life of 16,000 hours.

Standard efficiency 250 and 400 watt mercury vapor lamps are estimated to cost 430 and 615 Rupees respectively. The cost estimate does not include labor but does include a fixture change.

#1

Metal Halide

Supplier: General Electric/APAR Lighting
Dharmsinh Park
National Highway No. 8
Post Bag No. 3
Nadiad 387 001

phone: 23-322 or 23-522
fax: 91 0268 50255

contact person: Mr. R.J. Barco, Sales Manager

Technical Specifications:

Watts:	250		400	
Anticipated Life:		6,000		6,000 hours
Lumen Flux:	19,500		32,000	

Color Rendition Index:	70	70

Energy Consumption:

Savings kWh/year:	750	1,200
Savings Rupees/year:	1,875	3,000
Payback years:	2.0	1.4

Estimated Price in Rupees

Lamp Price:	1,300 x 2.7	1,500 x 2.7
Fixture (includes ballast) Price	1,500	1,750
Taxes:	included in price	included in price
Total Price:	5,010	5,800
Incremental Price:	3,830	4,310

Availability:

Indian States not having sales outlets: NIS

Comments:

Efficiency can decrease up to 25% after 200 hours of operation
Requires a separate ballast

#2
Metal Halide
Supplier: Philips India
Lighting Design and Engineering Center
P-65, Taratolla Road
Calcutta 700-088
phone: 714-245
fax: 033-714-247

Technical Specifications: Model: Crisp White Light

Watts:	<u>250</u>		<u>400</u>	
Anticipated Life:		NIS		NIS
Lumen Flux:	17,000		30,600	
Color Rendition Index:	69		69	
Color Temperature:	4300		4300	

Energy Consumption:

Savings kWh/year:	750	1200
Savings Rupees/year:	1,875	3,000
Payback years:	2.0	1.4

Estimated Price in Rupees

Lamp Price:	1,200 x 2.7	1,350 x 2.7
Fixture (includes ballast) Price:	1,500	1,750
Taxes lamp only:	120	135
Total Price:	4910	5,650
Incremental Price:	3,730	4,160

Availability:

Regional offices in the cities of: Calcutta, New Delhi, Bombay, and Madras.

Comments:

Also available in 70, 100, 1,000 and 2,000 Watts
Can only be used within 15º of vertical.
Most commonly used in indoor applications with the lamp over 4 meters off the floor.
Requires ballast

E. High-Pressure Sodium Vapor (Hps) Lamps

Technical Description:
HPS lamps are composed of a sodium discharge system operating at high pressure within a ceramic arc tube. They have very good to good color rendition. They typically have lives of 24,000 or more hours. HPS lamps have an efficacy of 60 to 95 lumen/watt depending on the bulb type.

HPS lamps most commonly replace mercury vapor lamps (which have efficacies between 25 to 40 lumens/watt, depending on the lamp type, and they operate for approximately 16,000 hours). The replacement results in a savings of approximately 60% and improves color rendition. In the US, some high-pressure sodium vapor lamps are designed to operate on mercury ballasts and fixtures, thereby reducing replacement costs significantly. Typically, one HPS lamp and fixture replace every two mercury vapor lamps/fixtures[12].

Energy Savings:
This conversion from mercury vapor lamps to HPS lamps results in an electricity savings of approximately 60%.

HPS lamps/fixtures can also replace fluorescent lamps/fixtures and incandescent lamps/fixtures. A 70-watt HPS lamp will emit as much light as two, four-foot fluorescent lamps with a 20% decrease in energy usage. A 70-watt HPS lamp will emit as much light as six, 70-watt incandescent lamps and operate ten times as many hours.

Capital Costs:
HPS lamps cost between 500 and 1200 Rupees depending on their wattage and specifications.

1995/1996 Excise Tax: 10%

Estimated Simple Payback Period:
Estimated payback periods range from 0 to 5 years depending on the lighting type they are

[12] Low-pressure sodium lamps can replace mercury vapor lamps where good color rendering is not required. The best low-pressure sodium lamps have an efficacy of 200 lumen per watt. (These lamps are not currently available in India.)

replacing and the refixturing costs. In cases where HPS lamps replace incandescent lamps, the re-lamping costs can be paid for in incandescent lamp replacement costs alone. The conversion of fluorescent and mercury vapor lighting systems to HPS systems have longer payback periods.

Estimated Number of Standard-Efficiency Devices Currently in Place:
Standard-Efficiency Tube Fluorescent Fixtures

Sector	Industrial	Service	Agriculture	TOTAL
	13,000,000	8,100,000	6,100,000	27,200,000

Current Penetration of Efficient Device:
The current penetration of HPS lamps is less than 5% of the lamps operating in India.

Estimated Eligibility:
We estimate that about 30% of the Indian mercury vapor lamp stock is eligible to be retrofitted with HPS lamps.

Technical Energy Savings Potential:

Sector	Industrial	Service	Agriculture	TOTAL
replacements	4,600,000	1,200,000	930,000	6,730,000
savings (GWh)	240	18	17	275

Device Population Forecast:
HPS lamps have excellent growth potential, as HPS relamping is suitable at sites where incandescent, fluorescent, and mercury vapor lamps are currently used.

With the improvement of power quality, HPS lamps have excellent growth potential in street and outdoor lighting applications. Most (75%) of the street and outdoor lighting is provided by incandescent and fluorescent lamps (US FCS 1993).

Device-Specific Barriers:
HPS lamps operate poorly in areas with voltage problems (which are typically worst in rural areas).

Assumptions Used for Incremental Cost and Payback Calculations:
Determined based on 3,000 hours of use per year. Electricity cost of 2.5 Rupees/kWh is used for all calculations. Standard efficiency lamps are mercury vapor lamps of 125, 250, 400 and 1,000 watts, and have a life of 20,000 hours.

The 125-, 250-, 400- and 1,000-watt mercury vapor lamps are estimated to cost 165, 430, 615 and 2,700 Rupees respectively (Phillips June 1, 1994).

#1

High-Pressure Sodium Vapor Lamps

Supplier: Philips India
Lighting Design and Engineering Center
P-65, Taratolla Road
Calcutta 700-088
phone: 714-245
fax: 033-714-247

Technical Specifications:

Life: NIS hours

Model	**SON**				**SON T**			**SON T PLUS**			
Watts:	70	150	250	400	150	250	400	100	150	250	400
Lumen per watt:	82	90	100	118	93	108	119	105	107	120	138
Color rendition index:	NIS	NIS	NIS	NIS	NIS	NIS	NIS	NIS	NIS	NIS	NIS

Energy Consumption

Savings kWh/year:	165	300	450	1800	300	450	1800	165	300	450	1800
Savings Rupees/year:	412	750	1125	4500	750	1125	4500	412	750	1125	4500
Payback years:	1.0	0.3	0.1	instant	0.3	0.2	instant	1.6	0.5	0.3	instant

Estimated Price in Rupees (prices of June 1, 1994):

Lamp price:	565	615	715	865	650	760	995	815	815	920	1190
Fixture price:	1400	1500	1600	1800	1500	1600	1800	1500	1500	1600	1800
Taxes:	included in price				included in price			included in price			
Incremental Price :	400	185	100	-1835	220	145	-1705	650	380	305	-1510

Availability:

Regional offices in the cities of: Calcutta, New Delhi, Bombay and Madras.

Comments:

- Made by Philips in India
- The SON and SON/T lamps are for both indoor and outdoor applications, the SON/T lamps have about half the diameter of the SON lamps.
- The SON(T) Plus lamps has poorer color rendition, but has a longer life and is more efficient than the SON and SON/T lamps. It is best used at outdoor and industrial applications.
- Ballast is required (fixture cost includes ballast)

#2

High-Pressure Sodium Vapor Lamps

Supplier: Philips India
Lighting Design and Engineering Center
P-65, Taratolla Road
Calcutta 700-088

phone: 714-245
fax: 033-714-247

Technical Specifications:

Life: 24,000 hours

Color rendition Index: 65

Model:	**SON Comfort**			**SON T Comfort**		
Watts:	150	250	400	150	250	400
Lumen per watt:	82	88	95	80	92	100

Energy Consumption

Savings kWh/year:	300	450	1800	300	450	1800
Savings Rupees/year:	750	1125	4500	750	1125	4500
Payback years:	0.3	0.1	instant	0.3	0.1	instant

Estimated Price in Rupees (prices of June 1, 1994):

Lamp price:	615	715	865	650	760	995
Fixture price:	1500	1600	1800	1500	1600	1800
Taxes:	included in price			included in price		
Incremental Price :	185	100	-1835	220	145	-1705

Availability:

Regional offices in the cities of: Calcutta, New Delhi, Bombay, and Madras.

Comments:

- Made by Philips in India
- The SON Comfort and SON/T Comfort lamps is best used for outdoor and large scale indoor lighting where warm and appealing colors are desirable. The SON-T comfort lamp's diameter is half of SON Comfort lamp.
- Ballast is required (fixture cost includes ballast)

#3

High-Pressure Sodium Vapor Lamps

Supplier: General Electric/APAR Lighting
Dharmsinh Park
National Highway No. 8
Post Bag No. 3
Nadiad 387 001

phone: 23-322 or 23-522
fax: 91 0268 50255
contact person: Mr. R.J. Barco, Sales Manager

Technical Specifications:

Watts:	70	150	250	400
Lumen Flux:	5,740	13,500	25,000	44,000
Efficiency (lumens/watt)	82	90	100	110

Color Rendition Index: 22

Anticipated Life: 24,000 hours

Energy Consumption:

Savings kWh/year:	140	300	500	800
Savings Rupees/year:	350	750	1250	2000
Payback years:				

Estimated Price in Rupees

Lamp Price:	NIS	NIS	NIS	NIS
Fixture (includes ballast) Price:				
Taxes:				
Total Price:				
Incremental Price:				

Availability:

Indian States not having sales outlets: NIS

Comments:

Best for outdoor lighting where good color rendition is not needed.
Ballast is required (fixture cost includes ballast)

F. ML-N Blended Lamps

Technical Description:
These gas discharge lamps have the combined efficacy of high-pressure mercury vapor lamps and the favorable color properties of incandescent lamps. The bulb has a quartz discharge tube within a tube filled with inert gas. The outer lamp envelope is covered with a phosphor to improve color rendition. An internal tungsten filament acts as a ballast. Thus, this lamp does not require a ballast. These lamps are directly interchangeable with incandescent lamps (i.e., no fixture change is required).

These lamps have an efficacy of 18 to 21 lumens/watt (in contrast to an incandescent bulb which typically have an efficacy of 15 lumens/watt), making them the least-favorable alternative to incandescent lighting.

ML-N blended lamps are recommended for replacing high-wattage incandescent lamps. They are applicable at either indoor or outdoor settings where good color rendition is desired.

Energy Savings:
When replacing incandescent lamps, electricity consumption is reduced approximately 25%.

Capital Costs:
ML-N blended lamps cost approximate ten times as much as an incandescent lamp of the same wattage.

1995/1996 Excise Tax: 10%

Estimated Simple Payback Period:
Less than one year.

Estimated Number of Standard-Efficiency Devices Currently in Place:
Not estimated

Current Penetration of Efficient Device:
It is estimated that blended lamps have replaced less than 20% of high wattage incandescent lamps.

Estimated Eligibility:
It is estimated that 90% of the high-wattage incandescent lamps are eligible for replacement with blended lamps.

Technical Energy Savings Potential:
Not estimated.
Device Population Forecast:

With the relatively short payback period and lack of ballast or fixture costs, the penetration of blended lamps should be fairly rapid, although their high initial capital cost will limit sales.

Device-Specific Barriers:
None recognized.

Comments:
A blended lamp should be the last option considered when an incandescent lamp is to be replaced. Their efficiency is only nominally better than that of incandescent lamps.

Assumptions Used for Incremental Cost and Payback Calculations:
Determined based on 3,000 hours of use per year. Electricity cost of 2.5 Rupees/kWh is used for all calculations. Standard efficiency lamps are incandescent lamps of 200 and 300 watts having a life of 750 hours. Thus, 6.5 incandescent lamps are needed to replace one blended lamp over its 5,000 hour lifetime.

The 200- and 300-watt incandescent lamps are estimated to cost 22 and 57 Rupees respectively (Phillips June 1, 1994).

#1
ML-N Blended Lamps
Supplier: Philips India
Lighting Design and Engineering Center
P-65, Taratolla Road
Calcutta 700-088
phone: 714-245
fax: 033-714-247

Technical Specifications:

Life: 5000 hours		
Watts:	160	250
Lumen per watt:	18	20
Color rendition °K:	3600	3600

Energy Consumption

Savings kWh/year:	120	150
Savings Rupees/year:	300	375
Payback years:	0.25	

Estimated Price in Rupees (prices of June 1, 1994):

Lamp price:	220	NIS
Taxes:	included in price	included in price
Incremental Price :	77	

Availability:
Regional offices in the cities of: Calcutta, New Delhi, Bombay and Madras.

Comments:

- Made by Philips in India
- The 160-watt bulb can be installed within 30º of vertical. The 250-watt bulb can be installed within 45º of vertical.

- Recommended for replacing high-wattage incandescent lamps in low-bay workshops, factories, and garages, and outdoors on smaller roads and parking areas, and smaller commercial security lighting applications.

Efficient Electric End-Use Devices:
The Indian Market
Residential Appliances

January 1996

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with the support of the DSM Cell staff at
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for
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under
The Energy Management Consultation and Training (EMCAT) Project for India

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5.3 Residential Appliances

A. Residential Refreigerators

Technical Description:
Refrigerators used in India are among the most inefficient in the world. Their efficiency can easily be improved by using more and better insulation (replacing fiberglass with foam insulation), tightening door seals, increasing the efficiency of compressor and fans, increasing the surface area of the evaporator coil, and reducing the wattage of anti-sweat heaters and compressors (ACEEE, 1991 and EMC, 1993).

Indian refrigerators are relatively small, 185 to 320 liters (6.5 to 11.3 cubic feet) and typically have small freezer compartments. The freezers are generally defrosted manually. Many small manufacturers of refrigerators dominate the Indian market. They are known for producing relatively low-tech appliances. The market is segmented geographically.

In the last three years, many refrigerator manufacturers have begun selling improved-efficiency refrigerators with PUF (expanded polyurethane foam) insulation. PUF insulation alone can improve refrigerator efficiency by 10% (EMC, 1993).

None of the refrigerators currently available in India can be considered Aenergy efficient@, although there are models that are more efficient than others.

Energy Savings:
Improving insulation levels, door seals, and increasing fan and compressor efficiency results in an electricity savings of approximately 35% (ACEEE, 1991).

Capital Costs:
Refrigerator base capital costs range from 6,600 to 22,200 Rupees depending on volume, number of doors, and the manufacturer (see accompanying table).

Survey of Refrigerators Available in Ahmedabad India (AEC, 1995)
- no measure of their efficiency was available

Manufacturer			Base Price (not including taxes)		
	Size (liters)	Watts	single door	double door	triple door
BPL					
	185	120		9,664	
	230	120		13,550	15,150
	350	120			22,216
Godrej					
	165	140 - 190	6,627	9,168	
	230	140 - 190		9,402	
	240	140 - 190			12,481
	300	140 - 190	9,033		
Videocon					
	165	140 - 180	6,718	8,205	
	280	140			10,612

1995/1996 Excise Tax: 20%

Estimated Simple Payback Period:
Based on a sample from one manufacturer of Aenergy-efficient@ refrigerators (BPL), the payback period is estimated to range from 3 to 15 years depending on the size of the refrigerator, with the smaller refrigerators having a shorter payback.

Energy-efficient refrigerators can be made more cost-effectively. Efficiency improvements should not carry such a large cost. (The incremental cost of the efficient 185 liter refrigerator should be 700 Rupees rather than 1,750, thereby reducing the payback period to 1.5 years).

Estimated Number of Standard-Efficiency Devices Currently In Place:
5.2 million

Current Penetration of Efficient Device:
The current penetration of improved-efficiency refrigerators is less than 5% of the operating refrigerator stock.

Estimated Eligibility:
We estimate that about 90% of the Indian stock is eligible to be replaced by efficient refrigerators.

Technical Energy Savings Potential: Residential refrigerators currently account for approximately 15% of residential electricity demand. If 4.7 million standard-efficiency refrigerators were replaced by efficient refrigerators, it is estimated that 730 GWh could be saved.

TERI (1994), estimates that the development and penetration of a Asuper efficient@ refrigerator could save an estimated 1,500 to 2,300 MW by year 2000, and 5,200 to 7,700 MW across all of India by year 2010.

Device Population Forecast:
Annual Sales Estimate for all Refrigerators (US & FCS, 1995)

year:	1986	1993/94	1995/96	1997/98
sales:	>600,000	1,200,000	1,400,000	1,500,000

In the city of Pune (a booming city outside of Bombay with 1.2 million inhabitants), residential refrigerator ownership increased from 13% of the household to 23% between 1982 and 1989 (Kulkarni, 1994). This penetration is only expected to continue as the Indian middle class grows.

Refrigerator demand is anticipated to grow 16% each year between 1994 and 2000, and 10% each year between 2000 and 2010 (TERI, 1994).

It is anticipated that new purchases do, and will continue to, exceed refrigerator replacements.

Device-Specific Barriers:
To operate under the poor power quality conditions which typify Indian electrical grids, refrigerator compressor motors are typically oversized, thereby reducing their efficiency.

Technical data provided for Indian refrigerators does not include energy consumption information, thus, making it difficult for anyone interested in purchasing an efficient refrigerator to select one based on efficiency.

The more efficient refrigerators are typically accompanied by other options, which further drive up the refrigerator=s price.

Comments:
As of 1994, federal regulation precluded the import of refrigerators into India.

Large international corporations have already entered the Indian white goods markets by developing joint ventures with large Indian manufacturers. To rapidly increase production levels, the joint venture manufacturers typically out-source many of the components for their products. These out-sourced goods are of variable quality and efficiency.

Domestically made refrigerators have very low power factors, from 0.4 to 0.75, resulting in high distribution losses. By adding capacitors, at a cost of approximately 60 Rupees, the power factor could be brought up to 0.9 (EMC, 1993).

The Energy Management Center (EMC, 1993) tested a cross section of refrigerators available in India. For a 165 liter model, electricity consumption ranged from 1.21 to 3.12 kWh/day, while 165- to 300-liter models used 1.27 to 4.46 kWh/day. These rates are well above the voluntary norms set by the Indian Bureau of Standards for refrigerators (of 2 kWh/day for a 165-liter model and 2.25 kWh/day for a 300-liter model). In Thailand, where there has been a concerted effort to produce more efficient refrigerators, a 165-liter refrigerator similar to Indian models consumes 1.27 kWh/day (EMC, 1993).

Assumptions Used for Incremental Cost and Payback Calculations:
It is estimated that (1) standard-efficiency refrigerator of 185, 230 and 350 liters are of 190, 190 and 210 watts respectively, (2) they operate for 2850, 3540 and 4620 hours per year respectively, and (3) the price of electricity is 2.5 Rupees/kWh.

It is estimated that a standard-efficiency refrigerator of 185, 230 and 350 liters cost 9850 Rs. , 11,050 Rs. and 16,000 Rs. respectively.

#1

Residential Refrigerator

Supplier: BPL - Sanyo Limited
84 Mahatma Gandhi Rd.
Bangalore 560 001

Technical Specifications:					
Volume (liters)	185	230	230	350	
Doors	2	2	3	3	
Power (watts)	120	120	120	140	
Efficiency:		NIS	NIS	NIS	NIS
Anticipated Life: 15 years					
Energy Savings					
Electricity kWh/year:	200	250	250	325	
Electricity Rupees/year:	500	625	625	813	
Payback Period (years):	3.5	8.4	11.5	13.2	
Estimated Prices (Rupees)					
Price:	9,664	13,550	15,150	22,215	
Excise Duty:	1,933	2,710	3,030	4,443	
Total:	11,597	16,260	18,180	26,658	
Incremental cost:	1,747	5,210	7,130	10,658	

Availability:
Indian States not having sales outlets: NIS

B. Room Air Conditioning Units

Technical Description:
A room air conditioner is an encased device that is designed to cool one or two rooms. The air conditioner is composed of the compressor, fan, fan motor, and heat transfer coils. Each component of the air conditioner offers opportunities for efficiency improvements. The largest savings are available at the compressor. In India, compressor and compressor motor efficiency improvements have reduced compressor energy consumption by 25% (Carrier, 1994). Fan and fan motor efficiency improvements are also important because the fan runs constantly, while the compressor cycles on. Heat transfer coils can be made more efficient by increasing their size and improving their designs.

The standard air conditioner currently in operation in India has an EER (energy efficiency rating defined as its Btu of cooling output divided by the input watts of power) from 6.0 to 8.0. The most efficient air conditioners available in India claim to have an EER of 10.0. Efficient room air conditioners available in the U.S. have an EER of 12.

Energy Savings:
Electricity savings depend largely on the specifics of the application where the air conditioner is installed. Assuming that the efficient air conditioner has an EER of 9.0, the energy savings typically range from 20% to 40%, depending on the efficiency of the air conditioner being replaced.

Capital Cost:
ACEEE (1991) estimates that an efficient room air conditioner, with an EER of 9.0, would cost about an additional 2500 Rupees per ton cooling (adjusted to Rs. 1995) or an additional 15% to 25% of a 6.0 EER unit=s capital cost.

In India, air conditioners will require a stabilizer. Stabilizers are used to maintain a constant voltage to the air conditioner. They cost 2,400 to 3,100 Rupees depending on the size of the air conditioner.

A Survey of Room Air Conditioners Available in Ahmedabad India
(information collected by AEC and RMA in 1995)

Manufacturer	Size (tons cooling)	Watts	EER	COP[13]	Base Price (not including taxes)
Amtrex					

[13] Coefficient of performance is the ratio of the rate of heat removal to the rate of energy input in consistent units. COP is used in India, EER is used in the U.S.

	0.5	750	8	2.4	10,571
	1.0	1450	8.3	2.4	17,170
	1.5	2100	8.6	2.5	19,964
	2.0	2650	9.1	2.7	24,964
Bluestar					
	1.0	1800	6.7	2.0	15,714
	1.5	2100	8.6	2.5	18,929
	2.0	2800	8.6	2.5	25,000
Volga					
	0.5	750	8	2.4	10,571
	0.75	900	10	2.9	12,571
	1.0	1500	8	2.4	14,571
	1.5	2000	9	2.7	17,929
	2.0	2650	9.1	2.7	21,929
Videocon					
	0.75	1100	8.2	2.4	13,179
	1.0	1200	10	2.9	16,071
	1.5	1950	9.2	2.7	21,000
	2.0	2650	9.1	2.7	26,000
Sriram Tecumech					
	0.5	775	7.7	2.3	10,707
	0.75	900	10	2.9	12,850
	1.0	1450	8.3	2.4	15,350
	1.5	2000	9	2.7	19,279
	2.0	2500	9.6	2.8	23,921
Carrier (model: St. Moritz)					
	1.5	2000	9.0	2.7	30,700
	2.0	2800	8.6	2.5	37,100
Blue Star					
	1.0	1800	6.7	2.0	15,714
	1.5	2100	8.6	2.5	16,929
	2.0	2800	8.6	2.5	25,000

1995/96 Excise Tax: 40%

Estimated Simple Payback Period:
When an air conditioner with an EER of 9.0 replaces a unit with an EER of 6.0 with the incremental cost noted above, and the air conditioner operates for 1,600 hours annually, the payback period is less than one year.

Estimated Number of Standard Efficiency Devices Currently in Place:
Accurate estimate not available

Current Penetration of Efficient Device:

The current penetration of energy-efficient air conditioners is less than 10% of the air conditioners operating in India.

Estimated Eligibility:
We estimate that about 90% of the Indian room air conditioner stock is eligible to be replaced by more efficient models.

Technical Energy Savings Potential:
If 50,000 room air conditioners with a 6.0 EER were replaced by 9.0 EER air conditioners, then an etimated 625 GWh would be saved.

Device Population Forecast:
Annual Sales Estimates (US & FCS, 1995)

year:	1993/94	1995/96	1997/98
sales:	58,000	75,000	87,000

About 10% of the high income urban households had air conditioning in 1989, while the urban poor and all income brackets of rural households did not have any air conditioning (Kalkarni, 1994).

Room air conditioners are relatively uncommon in India, but the demand for them has been increasing and is anticipated to continue to grow. This is partly due to the growing middle class and the recent (1995/96) decrease in federal excise taxes on air conditioners from 60% to 40%. It is thought that most room air conditioners will not replace old units but will be purchased by first-time buyers.

Air conditioners are also an important and rapidly growing component of demand in the commercial sector. It is estimated that 25,000 air conditioners are in operation in the city of Ahmedabad (population about three million) (AEC, 1995). Most of these are located in commercial/industrial shops and offices.

Device-Specific Barriers:
High excise taxes on air conditioners deters the general public from purchasing air conditioners. The high tax rate also further encourages those purchasing an air conditioner to choose the lowest- cost air conditioner, which is typically the least efficient[14].

Comments:
The voluntary Indian Bureau of Standard's specifications call for room air conditioners to have a minimum energy-efficiency ratio (EER) of 6.6. to 7.0 for certification (ACEEE, 1991).

Fan power factors on Indian-made air conditioners are low. EMC (1993) recommends that

[14] The government of India should consider basing excise taxes on the efficiency of the air conditioner, with tax rates decreasing with increasing efficiency.

manufacturers install capacitors on fan motors to improve their power factor.

Central air conditioning is relatively uncommon, except for in better hotels and some large office buildings.

Assumptions Used for Electricity Savings Calculation:
Calculations are based on an efficient air conditioner with an EER of 9.0 and operating for 1,600 hours annually. Electricity cost of 2.5 Rupees/kWh is used for all calculations.

#1
Room Air Conditioners
Supplier: Blue Star Limited
Package Air Conditioner Division
Brand Box House, Prahadevi
Bombay
phone: 493-3101

Technical Specifications:

Model	A-300	A-450	A-600	
Tons of Refrigeration:	1.0	1.5	2.0	
Nominal Cooling Cap.:	11,905	17,860	23,810	Btu/hour
Capacity:	1800	2100	2800	Watts
Maximum Current:	6.7	8.7	12.8	amps
Energy Efficiency Rating:	6.7	8.5	8.5	Btu/hr/watt

Rated Voltage: 230 volts, single phase and 50 Hz
Anticipated Life: 15 years

Estimated Price in Rupees

Model	A-300	A-450	A-600
Price:	15,714	16,929	25,000
Excise Duty:	6286	7571	10,000
Voltage Stabilizer:	2450	2650	3110
Installation:	750	750	750
Total:	25,200	27,900	38,860

Annual Electricity Use (kWh):	2880	3360	4480
Annual Electricity Savings (kWh):	720	200	270
Annual Electricity Savings (Rs.):	1800	500	675

Availability:
Indian States not having sales outlets: NIS

#2

Packaged Energy-Efficient Room Air Conditioners

Supplier: Carrier
6&7 D.D.A. Market,
South Extn.-1
New Delhi 110065
phone: 462 6973 or 4669 4741
fax: 463 4007

Technical Specifications: Model St Moritz

Model: St. Moritz

Tons of Refrigeration:	1.0	1.5	2.0	
Nominal Cooling Cap.:	NIS	18000	24000	Btu/hr
Power Consumption:	NIS	2000	2800	watts
Energy Efficiency Ratio:		9.0	8.57	Btu/hr/watt

Power Supply: 230 volts, 50 Hz, single-phase
Operating Voltage: 187 to 253 volts
Anticipated Life: 15 years

Estimated Price in Rupees

Basic Price (includes 40%excise duty):	24,500	30,700	37,100
12% sales tax:	2,940	3,684	4,452
Voltage Stabilizer:	2,450	2,650	3,110
Installation:	850	850	850
Total:	30,740	37,884	45,512

Annual Electricity Use (kWh):	3200	4480
Annual Electricity Savings (kWh):	none	244
Annual Electricity Savings (Rs.):	none	610

Availability:

Indian States not having sales outlets: NIS

Comments:

Carrier/ India is a subsidiary of Carrier USA.
This air conditioner is manufactured in India using 100% Indian components.

#3

Room Air Conditioners

Supplier: Carrier
6&7 D.D.A. Market,
South Extn.-1
New Delhi 110065
phone: 462 6973 or 4669 4741
fax: 463 4007

Technical Specifications: Model Mistral

Model: Mistral	1.5		2.0	
Tons of Refrigeration:	1.5		2.0	
Nominal Cooling Cap.:	18,000		24,000	Btu/hr
Power Consumption:	2000		2800	watts
Energy Efficiency Ratio:	9.00		8.57	Btu/hr/watt

Power Supply: 230 volts, 50 Hz, single phase
Operating Voltage: 187 to 253 volts
Anticipated Life: 15 years

Energy Savings

Electricity kWh/year:	1070	1340
Electricity Rupees/year:	2670	3360
Payback years:		

Estimated Price in Rupees

Basic Price (includes 40%excise duty):	32,900		39,300	
12% sales tax:	3,948		4,716	
Voltage Stabilizer	2,650		3,110	
Installation		850		850
Total	40,348		47,976	

Annual Electricity Use (kWh):	3200	4480
Annual Electricity Savings (kWh):	none	244
Annual Electricity Savings (Rs.):	none	610

Availability:

Indian States not having sales outlets: NIS

Comments:

Carrier/ India is a subsidiary of Carrier USA.
This air conditioner is manufactured in India using 100% Indian components.

#4

Packaged Energy Efficient Room Air Conditioners

Supplier: Sriram Tecumech
NIS

Technical Specifications:

Tons of Refrigeration:	0.5	0.75	1.0	1.5	2.0	
Nominal Cooling Cap.:	6000	9000	12,000	18,000	24,000	Btu/hr
Power Consumption:	775	900	1450	2000	2500	Watts
Energy Efficiency Ratio:	7.75	10	8.3	9.0	9.6	Btu/hr/watt

Anticipated Life: 15 years

Estimated Price (Rs.)

Basic Price:	10,707	12,850	15,350	19,279	23,921	
Excise Tax:	4,283	5,140	6,140	7,711	9,569	
Voltage Stabilizer	2,250	2,350	2,450	2,650	2,810	
Installation		750	750	750	750	750
Total	17,990	21,090	24,690	30,390	37,050	

Annual Electricity Use (kWh):	1240	1440	2320	3200	4000
Annual Electricity Savings (kWh):	170	none	180	none	none
Annual Electricity Savings (Rs.):	425		450		

Availability:

Indian States not having sales outlets: NIS

Comments:

Carrier/ India is a subsidiary of Carrier USA.
This air conditioner is manufactured in India using 100% Indian components.

Efficient Electric End-Use Devices: The Indian Market

Capacitors

January 1996

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Madison, Wisconsin, USA

with the support of the DSM Cell staff at
Ahmedabad Electricity Co. LTD.
Ahmedabad, India

for
United States Agency of International Development
under
The Energy Management Consultation and Training (EMCAT) Project for India

Contract Number: 386-054127-C-00-4100-00

5.4 Power Factor Correction Panel and Capacitors

Technical Description:
In many applications capacitors are required to reduce power factor[15]. Inductive loads (e.g., from motors) cause a lagging power factor and capacitors cause a leading power factor. By installing appropriately sized capacitors, or banks of capacitors, at electric end-use devices or device groups, power factor can be improved. Power factor improvement results in reduced transmission and distribution technical losses (reducing peak demand and the need to oversize transmission, distribution, and generation facilities).

Low power factor is generated by reactive loads, such as underloaded motors. Power factor can be improved by properly sizing motors, but in many cases where motor load is variable, power factor is typically low and motors cannot be downsized.

Energy Savings:
Electricity savings depend largely on the specifics of the application. KVar savings typically depend on the specific application.

Capital Costs:
Capacitors and correction panels typically cost 100 to 250 Rupees/kVar in India.

1995/1996 Excise Tax: 10%

Estimated Simple Payback Period:
Payback period is highly case-specific; in some cases payback periods are less than one year.

Estimated Number of Standard-Efficiency Devices Currently in Place:
Not estimated

Current Penetration of Efficient Device:
The current penetration of power factor correction panels or capacitors is not known. Penetration rates are known to be very low in the small industry, residential, and commercial sectors. In the high-tension industrial sector, which are typically charged for low power factor, capacitor penetration is much higher.

Estimated Eligibility:
Not known

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15 Power factor is the ratio of the resistance power to the total in an AC circuit. Low power factors cause higher currents to flow in power transmission and distribution lines to deliver a given KW to an electrical load.

Technical Energy Savings Potential:
Not estimated

Device Population Forecast:
If utilities begin charging their customers power factor penalties, demand for capacitors/power factor correction panels would surge. To do this, electric utilities would have to install power factor metering and measurement instruments. The estimated 1995 market size for capacitors is $US 350,000,000 (US&FGS, 1994).

Device-Specific Barriers:
Currently, utilities may on charge their high-tension industrial customers for low power factor. Thus, most customers have little financial incentive to improve their power factor. Those customers with a low power factor who wish to increase the load on their already fully loaded electrical systems, or customers with captive power plants, will have a financial incentive to improve their power factor.

Similarly, manufacturers do not have an incentive to install capacitors on devices (e.g., evaporative coolers, refrigerators, etc.).

Comments:
Capacitors are made by more than fifteen firms in India. The largest producer being HHEL and Khatau Junker. Both firms have Atie-ups@ with General Electric U.S.A.

#1
Power Factor Correction Panel
Supplier: Crompton Greaves Limited
1, Dr. V.B. Gandki Marg,
Bombay 400 023
phone: 0220-277-525 or 276-610
fax: 022-202-8025

Technical Description: COS-matic Automatic Power Factor Correction Panel
Automatically maintains a high power factor to minimize inductive losses for industrial loads. Uses a microcomputer to control current limiting conductor circuits and capacitor banks. Benefits include: reduced KVA demand from own generators, ending power factor penalty charges, reducing demand KVA charges, and improves power system=s overall efficiency.

Technical Specifications:
Anticipated Life: NIS
Panel Ratings Available: from 35 to 350 KVAr
Rated Current Available: from 49 to 490 amps
Rated Voltage: 400 to 440 volts AC, 3 phase
Rated Frequency: 50 Hz
Allowable Over and Under-Currents: 1.1 Vn, 1.3 In

Energy Savings

Typical Simple Payback: NIS

Estimated Price in Rupees

Price: NIS

Availability:

Regional offices in the cities of: New Delhi, Calcutta, Bombay and Madras

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#2

Capacitors

Supplier: Crompton Greaves Limited
1, Dr. V.B. Gandki Marg,
Bombay 400 023
phone: 0220-277-525 or 276-610
fax: 022-202-8025

Technical Description: LT-Capacitor

Directly connects to the reactive loads (i.e., motors, welding transformers, etc.) to improve power factor. Benefits include: reduces power factor penalty charges, reduces demand KVAr charges, improves power system=s overall efficiency, reduces need for oversized power distribution system.

Technical Specifications:

Anticipated Life: NIS
Capacitor Ratings Available: in 3, 4, 5, and 6 KVAr sizes, higher rates obtained by banking individual units
Dielectric Losses: maximum of 0.5 watt/KVAr
Rated Voltage: 415 to 440 volts AC, 3-phase
Rated Frequency: 50 Hz

Energy Savings

Payback resulting from KVAr savings is 12 to 15 months depending on the power tariff (estimated by Crompton Greaves).

Estimated Price in Rupees

Price: NIS

Availability:

Major Indian cities having distributors: New Delhi, Gaper, Jalandar, Lucknow, Calcutta, Gauhati, Patna, Bhubaneshwar, Bombay, Ahmedabad, Indore, Nagpur, Pune, Vadodra, Madras, Bangalore, Secunderabad, Cochin, and Coimbatore

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#3

Capacitors

Supplier: Larson and Toubro Limited
10 Club House Road
Anna Road
Post Bag NO. 5247
Madras 600 002

phone: 826 2141

Technical Description: Power Capacitors

Mixed dielectric or metalized film polypropylene type capacitors to suit a wide range of applications
Each equipped with a built-in fuse.
Tropicalized and suitable for 50^{o}C ambient

Technical Specifications: NIS

Energy Savings

Payback resulting from KVAr savings is 12 to 15 months, depending on the power and demand tariffs (estimated by Crompton Greaves).

Estimated Price in Rupees

Price: NIS

Availability:

Major Indian cities having distributors: Calcutta, Pune and New Delhi

Comments:

Manufactured by Meher Capacitors PVT. LTD. of Bangalore

#4

Capacitors

Supplier: Mysore Sales International Limited
36, Cunningham Road,
Bangalore 560 052
phone: 226 4021 - 28
fax: 225 3311

Technical Description:

Available in 1 to 60 kV in standard rated voltages of 415 or 440 volts, and 660 volts AC
Delta connected, three phase, 50 Hz AC

Energy Savings

Payback resulting from KVAr savings is 12 to 15 months, depending on the power tariff (estimated by Crompton Greaves).

Estimated Price

Price: 200 Rupees./kVar
Taxes: 20 Rupees./kVar

Availability:

Major Indian cities having distributors: Bombay Calcutta and New Delhi

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#5

Capacitors

Supplier: Yesha Electricals PVT. LTD.
C-2/18, Industrial Estate
Gorwa Road
Baroda 390 016
phone: 320 201, 320 271
fax: 0265 325 980

Technical Description

Single or three phase capacitors available
Rated frequency 50 to 100 c/s

Energy Savings

Payback resulting from KVAr savings is 12 to 15 months, depending on the power tariff (estimated by Crompton Greaves).

Estimated Price in Rupees

Price: 6,600 Rupees for a 55 kVar capacitor or approximately 120 Rupees/kVar

Comments:

Manufactured in collaboration with Maxwell Laboratories of the U.S.

Bibliography

American Council for an Energy Efficient Economy, 1995, Electricity End-Use Efficiency: Experience with Technologies, Markets, and Policies Throughout the World, by M.D. Levine, J.G. Koomey, L. Price, H. Geller, and S. Nadel, Energy, volume 20, number 1, pages 37 - 61.

American Council for an Energy Efficient Economy, 1991, Opportunities for Improving End-Use Efficiency in India, by Steven Nadel, Virendra Kothari and S. Gopinath, published by ACEEE, Washington D.C., 245pages.

AEC (Ahmedabad Electricity Co.), 1995, personal communications with the staff of the AEC DSM Cell.

Energy Management Center, 1993, Energy Conservation Measures in the Domestic Sector, published by the Energy Mangement Center, New Delhi, India, 90pages.

Kalkarni A., Sant G., and Krishnayy J.G., 1994, Urbanization in Search of Energy in Three Indian Cities, Energy the International Journal, Volume 19, pages 549 - 560.

Tata Energy Research Institute (TERI), 1994, Super Refigerators: Savings Opportunities for Indian Utilities, published by the International Institute for Energy Conservation and The Tata Energy Research Institute, New Delhi, India, 4page.

Tata Energy Research Institute (TERI), 1995, TERI Energy Data Directory and Yearbook: 1994/95, Pauls Press, New Delhi, 317 pages.

National Lighting Product Information Program, 1991, Electronic Ballasts, Specifier Report Volume 2, number 3, published by the Lighting Research Center, Troy N.Y., 48 pages.

Storm R., Lord D., and Wagner L., 1992, Seizing the Moment: Global Opportunities for the U.S. Energy Efficiency Industry, International Institute For Energy Conservation, Washington D.C., 217 pages.

US&FCS, 1994, India Commerical Guide 1995, From the US Department of State National Trade Data Bank, available from the NTDB gopher at gopher://sunny.stat-usa.gov

US&FCS, 1995, India - Appliance Market Overview, US Department of State, National Trade Data Bank, serial number IMI940817.

Appendix 1
Business Support Services: U.S.

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Business Support Services: U.S.

(This section is largely excerpted from US&FCS, 1994)

The U.S. Department of Commerce and the U.S. and Foreign Commercial Service (US&FCS) and U.S. Embassies in India seek to promote U.S. investments which enhance the export of U.S.-origin goods and services to India. U.S. government commercial and trade promotion services include:

- Embassy officers in the Economic and Commercial Sections can provide client-confidential advice and counsel to interested U.S. firms. For more information, please contact the U.S. Embassy or one of the U.S. domestic offices of the U.S. and Foreign Commercial Service (listed in the government pages of your telephone directory). The Commercial Office at the American Embassy in New Delhi (phone number 91 11 600 651 and fax number 91 11 687 2391) will provide information on upcoming trade fairs and business opportunities to interested U.S. firms.

- U.S. firms considering entering or increasing their sales in the Indian market find participation in events sponsored by the U.S. Department of Commerce and the U.S. and Foreign Commercial Service (US&FCS) in India to be excellent vehicles for promoting business in India. Interested firms should contact the Office of South Asia (telephone: (202) 482-2954 or fax: (202) 482-5330) at the U.S. Department of Commerce, International Trade Administration, Washington, D.C.; the nearest district office of the U.S. International Trade Administration (located in major cities and listed in the U.S. Government pages of the telephone directory); or the US&FCS offices at the U.S. Embassy in New Delhi, one of the U.S. Consulates General in Bombay, Calcutta, or Madras, or the US&FCS field office in Bangalore.

- US&FCS India offers an agent distributor service for a user fee of USD 250 per post. On the basis of information provided by the U.S. client, a commercial specialist with industry expertise seeks to match the business interests of an exporter with three or more potential candidates. We provide a snapshot description of the market, identify the Indian firms who have expressed interest, and give an evaluation of their strengths and weaknesses. The Agent Distributor Service is a customized overseas search for qualified agents, distributors, and representatives for U.S. firms. We produce up to six foreign prospects that have examined the U.S. firm's product literature and expressed an interest in doing business in India.

- US&FCS India offers a World Traders Data Report (WTDR), a means of checking the reputation, reliability and financial status of prospective Indian trading partners. Information in a WTDR includes type of organization, year established, product lines, size, business reputation, principal owners, financial and trade references. A recommendation from the nearest US&FCS office as to the suitability of the Indian company as a trading partner for a U.S. firm is included. The user fee for this report is USD 100 as of June 1994.

Business Support Services: India

India's private businesses are organized into three leading business organizations. These organizations should be contacted by firms interested in entering the Indian market.

$ Associated Chambers of Commerce (Assocham)
Assocham is the oldest national organization of the Chambers of Commerce in India. It is non-political, seeking a close working relationship with the Government and representative business and commercial organizations.

$ Confederation of Indian Industry (CII)
The CII has more than 2,000 corporate members whose total capital investment is over USD 33 billion. CII members include public enterprises (Oil & Natural Gas Corp., Gas Authority of India, Ltd., Steel Authority of India Ltd.) as well as the major private business houses of India. The CII organizes trade fairs, conferences, and meetings. It has signed a Memorandum of Understanding with the U.S. National Association of Manufacturers.

$ Federation of Indian Chambers of Commerce and Industry (FICCI).
FICCI was established in 1927 as a central organization of industry, trade and commerce in India. The Government has invited FICCI to join over 100 advisory bodies for policy review and recommendation. FICCI organizes trade fairs, conferences, and workshops to serve its members. FICCI has a longstanding relationship with the U.S. Chamber of Commerce (Washington, D.C.).

Appendix 2
A Guide to Current Import Tariffs
Appendix 2
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A guide to current import tariffs, arranged by their Indian AHarmonized Schedule number@, is available from:

Chief Controller of Imports and Exports
Ministry of Commerce
Udyog Bhawan
Maulana Azad Road
New Delhi 110 001
Telephone: 91-11-301-1938 or 301-1275

The India Desk at the U.S. Department of Commerce (Washington, D.C.) may also be able to give you the specific rate of duty if you know the HS number for your product.
Telephone: (202) 482-5149 Fax: (202) 482-5330.