9 URBAN ENERGY MANAGEMENT

Prem K. Kalra and Rajiv Shekhar

India's cities are the engines of her economic growth. To provide an environment conducive to the buzz of economic activity that urban India must engage in, improvement of physical infrastructure has become a major objective of the planners. Energy is a vital component of urban infrastructure. Be it water supply, sewerage network, transportation, construction, manufacturing, information and communication technology (ICT) or provision of social infrastructure to enhance quality of life, energy in the form of electricity, oil and gas is an inescapable necessity to enable infrastructure development. An integrated approach for (i) providing uninterrupted supply of energy, (ii) promoting energy conservation and (iii) minimizing total energy costs would be the focus of this chapter.

We don't usually realize the extent to which we depend on various forms of energy to get through each day. Let us say, Mumbai is in the grips of a power failure for 72 hours at a stretch. What would the experience of a Mumbaiker be?[1]. In the first twenty four hours, the sudden break from the daily grind would probably be enjoyable. Not much work at office, one returns home early. The trains don't run, so of course there are commuting problems and traffic snarls. But then, on the flipside, once you are home, the TV won't disrupt peace, the neighbour's radio won't blare. As evening falls, not being able to tune into the news could be a bit irritating though. Candle light dinner at home could be enjoyable. But the night is stuffy, sweltering, and restless. By the second day the blackout would start affecting normal life in a serious way. The milkman may not deliver milk because pasteurization plants do not work without power; the newspaper cannot be delivered as the printing press is not functioning; the mobile phone discharges; and so does the laptop. One is nearly cut off from the outside world by now. If your landline phone works without power supply, there is probably a chance that friends and relatives may still be able to get in touch. They may even be able to reach you news about your city and your area, especially to gauge when electricity might be restored in your area. On your landline phone, you could reach your vendors for fruit and vegetable, milk and laundry. No vendor, however, is interested in climbing nine floors to reach you. By the evening, as daily household provisions run out, panic sets in. Bread, milk, dry-cell batteries, and candles are sold out by the time you make a run on the neighbourhood stores. When power will be restored becomes the topic of the day in the colony. Before the night is out, water tap runs dry and you are forced to go to bed worrying about where to fetch water from the next morning. Municipal water supply stopped on the first day itself. The morning of day three, the condition turns really bad. You are forced to eat leftover food that is beginning to rot, given that your refrigerator has not been running. You rely on your wits to put together a meal from the dry provisions available at home. The situation can turn worse if you have young children or old and ailing parents at home. Somebody needs the nebulizer. Somebody needs hot water. In the meantime your gas runs out. Isolation from the civilized world is complete.

PRESENT STATUS

The industry suffers from an 'energy-crunch' all the time. Of the various forms of energy consumed by the urban population, the major proportion is in the form of electricity. Per capita consumption of fossil fuels is still very low in urban India as compared to other developed countries hence we focus in this

[1] Experience in other class I cities may be different but any city with high rise buildings will have same problems. As we depend more and more on computers, if there is no electricity for more than eight hours continuously, offices become dysfunctional.

Views expressed in the chapter are of the authors.

chapter mainly on the management of power consumption. From educational institutions to hospitals, from commercial establishments to households, insufficient power supply causes tremendous hardships in several major cities across the country. With increases in income, the demand for energy evolves from basic energy end uses, such as cooking and lighting, to mobility, communication, space conditioning, and entertainment, all of which need larger quantities and different forms of energy. In Kanpur, citizens have reacted violently on several occasions to the continuous power cuts inflicted by KESCO, the local distribution company. Moreover, poor power quality is taking its toll on the life of distribution transformers, industrial machines, and domestic appliances. Commercial establishments respond to power cuts by using generators, which not only increases costs but also contributes significantly to air and noise pollution. In fact, air pollution caused by diesel-powered generators, is a major concern today.

Energy efficiency and conservation measures, beyond compact florescent lamps (CFLs), are conspicuous by their absence. Most electrical appliances and even LPG burners are not benchmarked for efficiency—the major concern for the manufacturers being the cost. It is common to see lights switched on in sun-lit areas of public/government institutions during the day. Simple steps in the use of the omnipresent, energy-guzzling air conditioners, such as proper regulation and temperature control are routinely ignored. Many industries still use antiquated high-energy consuming equipment; partly because of the non-availability of capital to replace them with energy-efficient equipment and partly because of power theft.

With the failure of the public distribution system, the urban poor are forced to either buy low efficiency fuels such as kerosene or low quality coal from the market (Table 9.1). Legal supply of electricity is still a distant dream for many urban poor families. And, even if the government provides subsidy for electricity, it is not likely to reach them because of an inadequate distribution infrastructure.

The opportunity costs of poor energy infrastructure can indeed be staggering (Box 9.1). Hence the big question arises: are Indian cities managing their energy needs efficiently? Unfortunately, beyond the 'adhoc' arithmetic of supply and demand and court-mandated implementation of 'green energy', management of energy for sustainable development has not attracted the attention it deserves. In fact, the concept of urban energy management (UEM) is not well understood at all.

Energy is available in various forms: electricity, CNG, LPG, and fossil fuels. Its usage is all-pervasive. Conventional planning entails separate estimates of a city's needs for each form of energy. Most cities don't even have projections of their energy requirements, leave alone strategies to tackle projected shortages. Issues such as substitution of energy sources or even concepts of energy convergence have not been given much attention. A plan of action to combat the adverse environmental impact of energy consumption is also missing. The optimum mix of energy sources to ensure sustainable and reliable energy delivery has not even been thought of. Energy conservation issues are normally given a 'go by.' With the increasing gap between supply and demand of energy, issues such as energy sufficiency and efficiency merit serious attention.

Table 9.1
Conversion Efficiency of Fuels used for Cooking (per cent)

Fuel	*Efficiency*
Commercial	
Soft coke/coal	10
Kerosene (in pressure stoves)	40
Kerosene (in wick stoves)	36
Liquefied petroleum gas	60
Electric hotplates	71
Non-commercial fuels	
Firewood (closed hearth)	16
Firewood (open hearth)	13
Twigs and straw (closed hearth)	16
Twigs and straw (open hearth)	13
Charcoal	16
Dung cakes	8
Biogas stove	55

Sources:

1. Data obtained from the (BIS) Bureau of Indian Standards, New Delhi (1984).
2. N.H. Ravindranath, and J. Ramakrishna (1997). 'Energy Options for Cooking in India', *Energy Policy*, 25(1), pp. 63–75.

Therefore, UEM entails the development of a strategic energy management programme that holistically integrates both the supply side and demand side management goals. In simple terms, UEM ensures a coordinated, long-term approach to ensure that the city's energy needs are met at the minimum cost to all sections of the society, without any discrimination. The strategic energy management programme should be reflected in an energy master plan (EMP) of the city.

Another motivation for UEM is energy security. Electrical energy consumption has grown by 25 per cent—from 446584 MU in 1998–9 to 559264 MU in 2003–4. The gap between electrical energy demand and supply was 7.8 per cent in 2001, with peak power shortage being as high as 13 per cent. Nearly 70 per cent of electrical capacity in India is based on the use of coal resources and nearly 75 per cent of the coal consumed is used for power generation purposes. Table 9.2 clearly shows that the gap between energy demand and domestic production of not only coal, but oil and natural gas, is likely to widen if the present trends of energy consumption continue, leading to a growing dependence on energy imports even in the short term. Clearly, use of energy has to be optimized to reduce our dependence on imports.

Box 9.1

Hidden Costs of Poor Infrastructure

David Foster

Hidden costs of poor infrastructure are among the most significant costs incurred in urban areas and yet they never show up on anyone's books. The following examples are illustrative of a much longer list:

The opportunity cost imposed on poor women and particularly young girls when they spend 2 to 3 hours per day fetching water for their families because of inadequate water infrastructure. Women must take time out from work and young girls frequently miss school in order to cope with inadequate services. Studies in Africa have shown that school attendance increased significantly when municipal water systems were improved.

The costs imposed on middle class families simply to cope with poor service typically far exceed the costs of providing good service. Inadequate infrastructure requires families to purchase stand by generators and tanks, pumps, and water treatment systems all simply to compensate for the failure of government to provide reliable service. When 'coping' costs are included, typical costs in India for water and power significantly exceed the cost of reliable services in Thailand and Singapore.

The opportunity cost to a factory owner when his expensive equipment must sit idle because of frequent power outages, is probably the single largest expense he incurs and yet it never shows up in the accounting records. Power looms sit idle in Bhiwandi (city near Thane and Navi Mumbai) for long periods each day because of frequent power outages. Storeowners frequently compensate with back up generators and yet these machines are far more expensive to operate (per kilowatt hour) and produce more pollution than a well managed central power plant. Unfortunately, these coping costs are hidden from view and rarely enter into the calculations when utility managers make decisions about tariffs and load shedding and maintenance.

Note: Views expressed are of the author of the box.

Table 9.2

Energy Demand–Supply Gap: 2006–7 and 2046–7

Fuel	2006–7 Demand	2006–7 Imports	Import dependence (per cent)	2046–7 Demand	2046–7 Imports	Import dependence (per cent)
Oil (MT)	129	94	73	702	622	88
Coal (MT)	453	54	12	1553	953	61
Natural Gas (MMSCMD)	180	81	45	550	513	93

Note: MT: Metric tonnes; MMSCMD: Metric million standard cubic metres per day.

Source: R.K. Pachauri and R.K. Batra (eds) (2001). *DISHA* (Directions, Innovations, and Strategies for Harnessing Action) *for Sustainable Development*, TERI, New Delhi.

For this reason, UEM should be linked to the strategic vision for the city based on the relative proportions of its industrial, commercial and domestic consumers, and their projected growth rates. Hence, the EMP must be integrated with the civil master plan of a city. This approach should address the present shortcomings of energy planning, insufficient stakeholder involvement, sub-optimal use of resources and lack of accountability.

It becomes imperative to take decisions about the role of different energy sources based on availability, calorific value, service conditions, and price. In energy planning and management it is important to understand that even though our country may have sufficient reserves, the demand-deficit cannot be fulfilled immediately. Setting up the supply chain right from exploration to distribution to the end user entails both time and investment. Hence an integrated resource planning (IRP) approach to meet urban energy needs on a sustainable basis should be adopted.

Integrated Resource Planning

The concept of IRP originated in the US and other developed countries in the 1970s. Till 1970s, improving lifestyles, increased use of electronic devices, low fuel prices, and competition among suppliers made it profitable for the utilities to produce and sell as much electric power as possible. Utilities responded to growing customer demand by building more power plants. The power industry did not promote energy conservation and did little to encourage customers to make their own energy-efficient improvements. As a result, the electric utility industry produced and is still producing, the majority of the sulphur dioxide emissions that cause acid rain, nearly one-fifth of the gases linked to the atmospheric greenhouse effect, and more than half of all nuclear wastes. Furthermore, up to 75 per cent of the electricity produced annually in the United States was wasted through the use of inefficient products and practices. However, the changing socioeconomic conditions and the regulatory environment have forced utilities to develop tools to balance their financial interests with society's goals of an energy efficient economy and a clean environment.

Integrated Resource Planning is a tool that allows cities to compare consistently the cost-effectiveness of all resource alternatives on both the demand and supply side, taking into account their different financial, reliability, and environmental characteristics. IRP, therefore, requires a clear-cut understanding of the quantum of energy required and its delivery mechanisms. This calls for the coordination of various institutions at city, state, and national levels. Topics related to technologies, fuels, non-conventional sources, governance structure, pricing methodologies, financing models, and legal issues have to be addressed. Proper implementation of IRP should result in the most cost-effective energy resource mix to satisfy a city's energy needs.

The IRP Process

The flowchart for a typical IRP process is given in Figure 9.1.

One possible sequence of activities in the integrated resource planning process can be as follows:

- Identify objectives: Reliability, sustainability, quality, and minimal impact on the environment.
- Assess current total energy loads and forecast future loads.
- Identify resource options that would bridge the demand–supply gap.
  - (a) Demand-side Options:
    - (i) Consumer energy efficiency: Energy-efficient appliances, lighting, heating and air conditioning, water heating, duct repair, motors, refrigeration, energy-efficient construction programmes, appliance timers and controls, thermal storage.
    - (ii) Utilities' energy efficiency: Load management, high efficiency motors, and reduced transmission and distribution losses.
    - (iii) Renewable source: Solar heating and cooling, wind, and day lighting
  - (b) Supply-side Options
    - (i) Identify energy sources: Electricity, CNG, LPG, Biomass and solar.
    - (ii) Co-generation and distributed generation.
- Evaluate identified resource options with respect to the objectives.
- Identify a mix of resource options that will meet/minimize the energy demand. The prioritization of alternatives along with their availability and cost would lead to the optimum resource mix.
- Plan energy distribution infrastructure.
- Implement IRP after getting approval from the appropriate administrative or regulatory bodies.

Estimating Energy Needs of a City

For the purpose of a typical city, energy needs can be broadly classified in terms of (i) infrastructure provision: construction, water, sewerage, transportation, (ii) commercial, (iii) domestic, and (iv) industrial. For each category, and the corresponding sub-category the type and quantum of energy required has to be determined and then projected. Load forecasting methodologies commonly used by electric distribution companies are a good starting point. Three basic methods used for forecasting are trend forecasting, econometric forecasting and end-use forecasting.

Trend forecasting

It assumes that past rates of change in electricity use per customer will continue into the future. A growth rate calculated from historical data (sales or peak demand data) may be applied to estimate future consumption and demand. Separate trending forecasts can be compiled for each energy category. Changes in technology, structural shifts in the economy or in demography, and changes in regulations are difficult to capture with a trending forecast. Trending is most useful for short-term forecasting (six months to one-year time span). This method is based on time series on the assumption that the future will be like the past. This is a robust assumption for a short duration forecasting.

Econometric forecasting

It assumes that past relationships between electricity use or peak demand and various economic and demographic variables affect the demand for electricity and the multi-variable dependence would continue to hold in the future. Econometric forecasts are generally more detailed than trending forecasts and perform well for longer than the one year horizon. Variables used to develop econometric relationships 'may include household income, energy prices (by consumer group), prices for other household necessities, employment (by sector and sub-sector), labour productivity, tourism, industrial output, and commercial-sector output (by sub-sector).

End-use forecasting

End-use forecasting differs from trending and econometric forecasting in that it builds up estimates of electricity needs

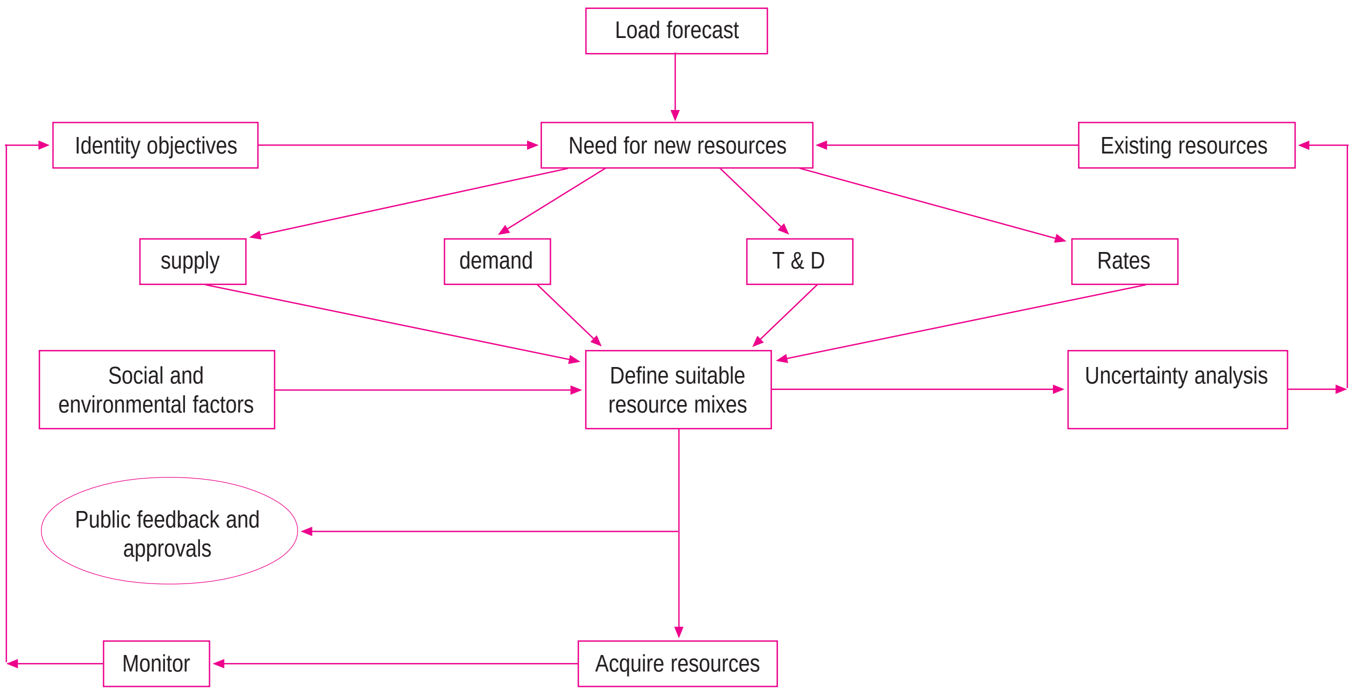

Fig. 9.1 Flowchart of a Typical IRP Process

starting with an analysis of what electricity is used for. An end-use model of household electricity use might include separate estimates of electricity used for lighting, water heating, space heating, air conditioning, fans, cooking, entertainment, and other appliances.

End-use approaches have several advantages. They can be quite detailed, providing more information for planners. They can provide integrated forecasts of both energy and peak power demands. The assumptions used in forecasting are usually easy to follow, check, and revise as new data become available. End-use forecasts provide an excellent framework for estimating the impacts of energy-efficiency options and demand-side management by making changes to parameters used in the baseline forecast.

Forecasting long-term energy requirements can best be done by combining the end-use and econometric forecasting methods. The end-use method can be used for estimating current energy needs, which in turn can be projected by established econometric forecasting techniques. Carrying out end-use surveys at stipulated intervals can help continuously refine projections.

Renewable Energy Sources

Renewable energy sources offer viable options to address energy shortage in urban areas. Today India is among countries with the highest potential for the effective use of renewable (Table 9.3). Bagasse, biomass, solar, and wind energy are plausible renewal candidates for energy generation. The major thrust of renewable has been to provide power in rural areas, especially where electricity transmission and distribution infrastructure is not available. However, solar-assisted energy generation, in terms of technology-readiness and viability, appears to be most appropriate for implementation in urban areas.

Table 9.3
Renewable Energy Potential and Achievements in India

Sources/technologies	Approximate potential	Achievement	
		As on March 2003	As on March 2004
Wind power (MW)	45,000	1870.0	2483.0
Small hydropower (up to 25 MW) (MW)	15,000	1509.0	1603.0
Biomass power/ cogeneration (MW)	19,500	483.9	613
Biomass gasifiers	–	53.4	58
Urban and industrial waste-based power (MW)	1700	25.8	–
Solar photovoltaics (MW/sq km)	20	121.0	151.0
Solar water heating (million sq m collector area)	140	0.7	0.8
Waste-to-energy (MW)	2500	25.8	41.5
Biogas plants (million)	12	3.5	3.7
Improved biomass *chulhas* (cookstoves) (million)	120	35.2	33.9

Source: MNCES (2004). *Annual Report 2003/04.* Ministry of Non-conventional Energy Sources, Government of India, New Delhi.

Box 9.2
Solar Photovoltaics: Applications and Case Studies

Solar PV for Outdoor and Traffic Lighting

Solar street lighting systems basically consist of a PV panel, inverter and storage battery connected to a light source. It can replace the conventional outdoor lighting system and operate for more than 8 hours a day. These systems have been installed in many industrial complexes and metro cities such as Delhi and Mumbai. The cost of solar street lighting would vary from Rs 18,000 to Rs 21,000 per system. These systems can be fitted with automatic sensors, which would turn the lights on/off depending on the intensity of natural light.

Solar Water Pumping Systems

Solar power is used for pumping water to agricultural and industrial use. These systems consist of solar panels, DC–AC converter in case of AC motors, flow optimizer, and a submersible pump. These systems can be installed in open wells and bore wells to the depth vary from 30 to 80 feet. Depending on the depth and solar radiation, water output would vary.

A tobacco processing company has installed a solar water pumping system with a total capacity of 11.5 kW, which has two 3.8 kW and one 3.6 kW systems. These three systems are connected to submersible pumps of 1.8 kW capacities and flow optimizers each. The capacity of the installed system is to cater about 20,000 kl of water per year. The total investment for this system is about Rs 55 lakh.

Solar Photovoltaic Power Plant

In a platinum rated Green Building in India, a 23 kW grid connected solar PV system has been installed. The system is mounted on the roof of the building and directed towards the south-east direction so as to have maximum sunlight. The system on an average generates about 100 units of electricity per day. About 17 per cent of the building's energy cost is being saved through the use of power generated from solar PV. The total investment required was about Rs 56 lakh (see Box 9.3 for further details).

Building Integrated Photovoltaic (BIPV)

Photovoltaic power systems integrated with building design allow for the possibility of combining energy production with other functions of the building envelope, including structural support, weatherproofing, shading etc. Cost savings through these combined functions can be substantial. Building Integrated Photovoltaic modules allow the designer to create environmentally benign and energy efficient buildings without sacrificing comfort, aesthetics, or economy. Cost of BIPV systems is site and location specific and would be higher than the normal solar PV system of same capacity. However, as BIPV systems are installed either on the roof or sidewalls of a building, the structural cost would be substantially reduced.

Source: CII–Godrej (2004). 'Solar Photovoltaic–Potential and Prospects', RES: Fact Sheet No.3, CII–Godrej GBC Publication, June.

Take the example of solar photovoltaics (Solar PV). India is potentially one of the largest markets for solar energy in the world. The estimated potential of power generation through Solar PV is about 20 MW per sq km in India, while the installed capacity is only 110 MW. It is useful for providing grid quality and reliable power. Solar PV can find applications both in industries, households, and for municipal operations such as street lighting. A few applications of SPVs in India have gained international recognition (Box 9.2).

In India, solar thermal systems are used both in the domestic as well as commercial and industrial applications. In the industrial sector, solar thermal energy is utilized for supplying process heat requirements. The resultant savings are mainly in terms of boiler fuel. In the commercial sector, solar water heating systems are used to meet hot water requirements in hotels, hospitals, and hostels. In the domestic sector, the replacement of electric geysers by solar water-heating systems[2], and supplementing LPG and firewood with solar cookers would result in lowering of recurring energy costs.

With increased urbanization, there has been a building boom, both in the residential and commercial sectors. Eighty-nine per cent of the urban households use electricity for lighting. Electricity consumption in the domestic sector alone accounted for 22 per cent[3] of the total energy consumed. Consumption in the commercial sector will increase this number substantially. Clearly this calls for the design of energy efficient buildings, of which the CII–Sohrabji Godrej Green Business Centre (GBC) in Hyderabad is a classic example (Box 9.3).

[2] As of December 2002, the total collector area installed was 680,000 sq m. The solar water heaters can effectively be used in the demand-side management, as approximately 1000 solar domestic water heaters (2000 sq m of collector area) can contribute to a peak load saving of 1 MW.

[3] This includes rural households too. But considering the pattern and quantum of usage, urban household consumption of electricity is expected to be much higher than rural household consumption.

Box 9.3

CII–Sohrabji Godrej Green Business Centre (GBC) in Hyderabad

While it may come as a surprise to many that the world's 'greenest' building stands on Indian soil, a reading of the specifications of the CII–Sohrabji Godrej Green Business Centre (GBC) in Hyderabad is enough to dispel any doubts. Designed by Vadodara-based architect Karan Grover, the 20,000 sq ft business centre, which stands on a five-acre site, uses the traditional Indian circular courtyard design to enhance air and light.

The design incorporates a number of energy-saving features. Two 45-feet wind towers and screen walls provide air pre-cooled by 10 degrees to the air-conditioning system, thereby reducing the amount of energy required for cooling. Says Grover: 'This is called the 'venturi effect' in modern buildings. It helps pre-cool the air.' Pointing out the lattice-work in a photograph of the Taj Mahal, he explains: 'It's not the first time for India. We have been doing it since ancient times.'

The Rs 6 crore structure also has photovoltaic panels built into it to generate solar energy that takes care of 20 per cent of the building's annual energy requirements. Likewise, the electrical fixtures have been automated to save power; 90 per cent of the building does not require any artificial lighting during the day because its circular design allows sunlight to reach every part of it. The building also boasts variable speed motors for its blowers and pumps, and the elaborate use of sensors feeding back to the controls.

Thanks to its circular design, fewer materials were used in the building's construction. Those that were, were recycled and eco-friendly—broken mosaic tiles, steel, wood, glass, fly ash brick, oil-and CFC-free equipment and the locally-available bettum cherla stone. Inside, all the carpets and paint are non-toxic. The workers employed in the building's construction were all local people.

Water is regarded as a precious resource—the building employs water-harvesting methods and wastewater is treated on-site and diverted for storage, to a water body on the edge of the plot, to be used for the garden. Here again there is a harking back to ancient architecture. 'The root zone water regeneration system we have used in the GBC is very common in Mughal gardens,' says Grover.

Given all these factors, bagging the title of the world's greenest building, awarded by the United States Green Building Council (USGBC), Pittsburgh, was a cinch. The council recognizes structures that combine new technologies and materials with energy-efficient architecture.

Source: CCDS (2003). *InfoChange News and Features*, Centre for Communication and Development Studies, Pune, December.

There is an important technical issue that merits attention. One major problem faced by solar-energy generation is the variation in the intensity of sunlight. These variations cause problems in the operation of alternators, which require constant speed to produce electricity at a specific frequency. Thus, most such energy generators are DC. But most electrical applications are designed for AC power. Hence the problem of cost-effective integration of DC power source with AC application has to be addressed. One viable option is to use the DC power source to charge batteries of inverters/UPS to provide electricity at home and offices. This solution will not only reduce electrical energy costs, but will continue to provide energy in areas where inverter batteries cannot be charged because of 'long' power cuts. Charging batteries through renewable energy has two more advantages. First, it reduces losses and harmonics in the electricity distribution system, thereby enhancing the life of equipment used for distribution. Second, use of small generators will be reduced and therefore an eco-friendly environment will be created through reduced emissions.

The obvious deterrent for the widespread adoption of solar PVs and solar heating, especially in households, will clearly be the capital and installation costs. To begin with, the use of renewable energy sources can be popularized by use in commercial buildings, industries, and municipalities.

Waste-to-Energy[4]

Municipal waste contains valuable raw materials and also energy, which can be reclaimed in a number of ways. Indian cities are increasingly producing large quantities of waste. Converting this refuse into energy can be a viable option. An estimated 48 million tonnes of solid waste and 5000 million cubic metres of liquid waste are being generated annually in the urban areas of the country. There exists potential for generating about 1500 MW of power from urban and municipal wastes and about 1000 MW from industrial wastes in the country. The installed capacity of waste to energy projects stands at 25 MW. A project for generating 4 MW power from starch industry solid waste is under installation at Samalkot in Andhra Pradesh.

In the USA, there are 89 biomass plants operating in 27 states managing about 13 per cent of America's trash, or about 95,000 tonnes each day. Biomass generates about 2500 MW of electricity to meet the power needs of two million homes, and disposes trash of over 36 million people. This US$10 billion industry employs more than 6000 American workers with annual wages in excess of US$400 million. A positive spin-

[4] See Chapter 8 on Solid Waste Management for problems and limitations of waste to energy projects facing in India.

off from this technology is that the trash volume is reduced by 90 per cent and the remaining residue consistently meets strict EPA standards allowing reuse or disposal in landfills.

Concerns have been expressed over the pollutants released by burning of solid wastes. However, developments in both generation technology and installation of pollution control equipment have the potential to reduce the collateral environmental problems significantly. For example, in the USA, according to EPA data, the dioxin emissions have decreased by 99 per cent in the past ten years, and mercury emissions have gone down by more than 95 per cent. With the double-headed monster of (i) increase in the generation of municipal wastes and (ii) difficulty in both collection and disposal of wastes, cities need to look at the waste-to-energy option seriously.

Convergence in Energy

One important objective of UEM is to decrease the total energy costs of a city. Electricity is the predominant energy form in terms of usage. Then there is CNG (compressed natural gas), a clean and cheaper fuel, which is now primarily used for transportation in selected metros. LPG is becoming the dominant medium for cooking, although the poor still rely on relatively more expensive[5], fossil fuel in urban India. The present supply and demand gap in electricity shows no signs of narrowing in the foreseeable future. Add to it the costs of strengthening the transmission and distribution infrastructure. Hence there has been a move towards distributed generation of energy. The present energy use raises the question: Can there be a convergence in energy sources for supplementing existing energy forms?

Definition

Energy convergence is the merging of electricity and natural gas industries. This convergence is developing from the combination of the need for additional electric generating capacity and the clear choice of natural gas as the fuel supply for this incremental generation. The restructuring of these markets will create significant opportunities in the new environment. Convergence of gas, electricity and other energy sources may hold the promise for developing countries as they often have rapidly growing energy demands and other environmental concerns. Potential advantages of gas-electricity convergence are seen to include greater energy security—especially if there is ready access to natural gas, greater efficiency from gas-turbine technology. Improved environmental conditions from clean burning gas shall be an added advantage.

[5] We have assumed that cost is inversely proportional to conversion efficiencies (see Table 9.1).

The convergence in energy can be exploited not only at the entry level but also in service level. The convergence of gas, electricity and other sources may be possible as follows: (i) technical convergence: the use of gas as a fuel in power generation, (ii) trading convergence: arbitrage and trading in gas and electricity commodities, and (iii) retail convergence: the joint marketing of gas and electricity, and possibly other utilities, to consumers.

Impact of Convergence

In power generation, the use of natural gas is leading to the emergence of a new market place where gas and electricity will be sold together and compete together. Energy retailing will continue to see increased competition with consumers having a greater choice of suppliers. In addition to the traditional risks such as erratic climatic conditions (rainfall, wind, etc.), technological deficiencies in new plants, unavailability of facilities, excessive operating costs can also be minimized using the concept of convergence of energy sources and usage patterns. Further, energy convergence can be utilized to reduce the volatility of fuel prices, volatility of electricity, deterioration of customer credit, volatility of exchange rates, instability of countries.

Implementation Model

With new gas finds and proposals to import gas from Iran and Bangladesh, CNG may be used as the main supplemental source of energy for a city's needs. The CNG supply to a city can be split into two streams. The first stream can be used for distributed power generation, while the second stream can be used for (i) transportation, (ii) domestic, and (iii) commercial use especially in heating.

Energy Conservation

Energy is a 'scarce' and 'precious' commodity for a rapidly developing country such as India. Energy intensity is extremely high in an Indian city compared to a similar-sized city in an advanced country[6]. It was pointed earlier that the energy intensity in India is 3.7 times of Japan, 1.5 times of the USA, and 1.4 times of an average Asian country. Table 9.4 compares the energy intensity of selected countries. It is also known that in India there is 13 per cent of peak shortage and 8 per cent of average shortfall of the electricity. Clearly, energy conservation must play an important role in policy endeavours.

[6] High-energy intensity is primarily a reflection of intensive, inefficient and wasteful use of energy and can be due to (a) use of low calorie fuel, (b) use of energy inefficient appliances, (c) low tariff, and (d) leakages in distribution. Energy intensity can also be a function of weather and the nature of economic activity, for example manufacturing vis-à-vis the services sector.

Table 9.4
Energy intensities for IEA Countries

GJ per capita		GJ per $1000 of GDP	
Luxembourg	355.7	Czech Republic	18.8
Canada	249.2	Hungry	13.2
United States	225.6	Turkey	11.4
Finland	203.6	Canada	10.8
Norway	196.4	Korea	8.5
Belgium	175.4	New Zealand	8.1
Sweden	164.0	United States	7.2
Netherlands	157.3	Australia	6.5
Australia	157.0	Finland	6.3
New Zealand	149.3	Portugal	6.3

Note: GJ Gigajoules; IEA International Energy Agency.
Source: GOC (2005). *The State of Energy Efficiency in Canada*, Office of Energy Efficiency Report 2005, Government of Canada, Gatinean.

Energy conservation in India started around 1970. However, the impact of this process was very mild, primarily because the costs involved in implementing energy saving methodologies were high. Now, with innovation in technologies and availability of affordable ways and means for energy saving and high use of energy for commercial purposes, the interest in energy conservation has been renewed. A recent report from CEA indicates that the sector-wise energy conservation potential is highest in agriculture (30 per cent) followed by the industrial sector (25 per cent).

Energy conservation has to occupy centre-stage in UEM. Hence the important question: what are the policy and technical inputs required for promoting energy conservation by minimizing energy losses in distribution and consumption[7]. Energy conservation is an all-encompassing concept and hence discussion in this section will focus on issues such as (i) energy efficiency, (ii) promoting energy conservation, (iii) importance of integrated transport, and (iv) environment.

Energy Efficiency

There are several definitions for energy efficiency. The simplest one is to break the link between economic growth and accelerating use of energy. That is, energy required per unit of output remains constant as per capita income rises. Techno-energy efficiency improvement means reduction in specific energy through technical improvement, change in behaviour, and better management. Hence there is considerable scope to improve energy management systems and consequently bridge the demand–supply gap.

Energy efficiency has three major impacts:

- Once energy efficient methods of delivery and generation are deployed and energy efficient appliances adopted, the money saved through procedures, processes or products can be used to purchase appliances that in turn would use more energy. This is called the rebounding effect. The money saved through energy efficiency mechanisms can lead to higher energy consumption.
- Energy saving and hence saving money may lead to economic growth through more investment in social infrastructure or donation for a good cause. This relates social efficiency with energy efficiency.
- Money conserved through energy efficiency could be invested to improve efficiency of use of energy, water and ecosystem services. This would amplify the impact of energy efficiency.

Energy efficiency is strongly linked with the quality of energy and quality of service (reliability, maintenance). For example, frequent shut downs lead to losses of revenue because energy is available but could not be utilized and hence it is not charged. The continuity of energy supply would reduce the burden on the product cycle leading to the use of optimal operating conditions. Energy efficiency along with optimal operating condition leads to a reduction in size of motors, and other equipment, which again contributes to savings. These saving can directly be used for the enhancement of production.

Energy efficiency can be attained at different levels. Energy efficiency in the full cycle of activities from converting energy at source to useful energy and then putting to application can be divided as follows:

- Production and distribution of energy: There are various mechanisms to convert source of energy to usable energy. This efficiency is generally very poor and therefore even incremental change in efficiency would contribute significantly (Table 9.3).
- Sectoral structures: The organization of sector is also responsible for various types of energy losses for example, transmission and distribution, losses in equipment as well as theft. How a distribution company can improve its performance is illustrated by the experience of Bangalore (Box 9.4).
- End user behaviour: The end user choice of appliances influences losses along with practices and habits. The labelling of appliance based on performance is a step towards assisting users to select appropriate appliances[8].

[7] Energy consumption relates to standards of living, economic growth, and development of new technologies.

[8] Energy labels are a critical element of an energy efficiency policy strategy as they provide the otherwise missing information on equipment energy use that is needed to allow demand and supply to interact on a level playing field. But there is both an art and science to creating an informative label that will guide consumers toward the appropriate purchasing decision. Poorly-designed labels can actually direct consumers towards the wrong product.

Box 9.4

Achieving Energy Efficiency by Performance Benchmarking

Bharat Lal, Pisupati Karthikeya, and Sri Vasuki

Background

The electricity industry in the country has been witnessing far-reaching changes in the last few years. Most of the state-owned boards have been unbundled vertically by creating new companies for generation, transmission, and distribution. Regulatory Commissions have been set up to ensure efficiency and economy in activities of electricity industry besides fixing the electricity tariffs in a transparent manner.

Despite these initiatives, the financial health of power utilities has been deteriorating. Even after un-bundling and separation of distribution function, very few companies have shown any efficiency improvement in the operational, financial and technical areas. There is a big gap between unit cost of supply and revenue and the annual losses of SEBs have been increasing and have reached unsustainable levels (Rs 17,593 crore per annum, 2002–3) (*Annual Report 2004–05*, Ministry of Power, India).

Distribution companies are being formed to focus on the retail supply and distribution of electricity. The government owned distribution companies cover a large portion of rural and urban centres compared to the private distribution companies. Private companies are managing the electricity distribution mainly in cities like Mumbai suburbs, Delhi, Kolkata, Baroda, Surat, etc.

Bangalore Electricity Supply Company (Bescom) is currently considered among the better managed electricity distribution companies in the country. Since its inception (June 2002), it has introduced several innovative interventions to improve its technical, operational, financial and operational performance levels.

Bangalore city alone consumes about 40 per cent of electricity generated by BESCOM and gives Bescom more than 60 per cent of its revenue. As part of its continued effort, Bescom decided to commission a study to benchmark the performance of cities in the country so as to know the standing of Bangalore city vis-à-vis other cities in terms of performance levels to discover areas of potential improvement.

The first and the most decisive step in the benchmarking study was to identify the performance parameters to be considered that could capture the core activities of electricity distribution business and that would make a critical difference to the functioning of the company.

The performance parameters included commercial (per cent AT&C losses, HT, LT, agricultural consumption pattern, units sold/consumer/year, average revenue/customer, per cent of collection efficiency, specific consumption-HT, specific consumption-domestic, average revenue per KWH sold, receivables in months of revenue), technical parameters (per cent of distribution losses, HT–LT ratio, per cent of transformer failure rate, number of consumers per sq km, distribution capex per unit sold [paise], distribution capex per consumer [in Rs]), labour productivity parameters (average revenue per employee, average man power per 1000 consumers, average man power per MU sold) and service parameters (complaints relating to metres, complaints relating to bills and payment, number of hours lost per customer, number of interruptions per customer).

The Development of the Benchmarking Study

From the information so captured, a power point presentation on the benchmark study was developed for all the 22 parameters. The presentation covered the approach and methodology followed, general information about the companies, performance of the companies on each of the technical, commercial, employee productivity, and customer related parameters. For all the four customer service related parameters namely, complaints relating to meters, complaints relating to bills and payment, number of hours lost per customer and number of interruptions per customer, no ranking was given since the data was available for only 4 cities out of 10.

In case of Hyderabad, it was later found out that certain circle data have not been included and hence the city data is incomplete. Similarly, there could be certain inconsistencies in the data captured also. We hope that this initiative would be supported by subsequent updates and perhaps over a period of time, the study can provide adequate data for fostering healthy competition between companies.

Key Results of the Study

Though, Reliance energy has the lowest LT–HT ratio and consequently lower loss, results for AEC, Hyderabad and Bangalore seem to be counter-intuitive to the common rule that lower LT–HT ratio results in lower losses. AT&C losses also seem to move closer to the distribution losses (except for certain re-ordering in the middle of the spectrum). This could basically be because the collection efficiencies in the cities tend to be closer to ideal levels. However, a clear distinction between technical and non-technical losses, GIS mapping, exact energy accounting would be needed to draw a broader conclusion about the networking structures between the cities. This could be an area that would assist the companies not only in improving technical performance but also in proper business valuation, when these companies intend to invite private sector participation.

The analysis of the parameters shows that there is no one utility which excels on all parameters. Reliance Energy, Mumbai leads in employee productivity followed by NDPL, Delhi in commercial parameters. AEC, Ahmedabad follows the two cities closely on commercial parameters. Interestingly, Hyderabad city leads on technical parameters followed by Bangalore city. Overall, benchmarking study reveals areas where a city distribution company can make improvements. More importantly, benchmarking quantifies extent of improvement, which a city distribution company can hope to achieve.

Note: Views expressed here are of the authors of the box.

- Regulatory mechanisms: Regulatory mechanism includes pricing, electricity codes, and benchmarking of performances and operation styles, which have direct impact on the different losses and energy efficiency.
- Service providers: Timely maintenance and replacement of poorly performing equipment improves system efficiency.
- Town planning: Proper energy planning can reduce the length of the conductor and unbalancing of three phases and hence major saving and improvement in performance of system.
- Quality of energy and its scheduling: Quality refers to the waveform of received supply and its closeness to the ideal waveform that is, harmonics, spikes and transients can distort quality. Losses are heavily dependent on the quality of supply and therefore remedies to improve quality can reduce losses.
- Reliability and sufficiency: Generally speaking reliability should mean provision of alternate routes of supply on the failure of given optimal route. This would only be possible when sufficient energy is available. This also suggests that fewer failures would lead to lower losses.
- Green and eco-friendliness: This relates energy efficiency with efficiencies of water, land use and the environment. This means the methodologies followed to improve energy efficiency should in no way contribute to inefficiencies related to water, land use and higher levels of loss to the environment.

The efficiencies mentioned above can be built in the subsystems through alternate lifestyle, education, community involvement and research and development. Energy indicators are used to cut across different sectors of energy and its management. Despite effective monitoring of the energy efficiency trends, the development of standards for energy efficiency indicators are still in their infancy. Such indicators are especially required for renewable and distributed generations.

Energy efficiency can be benchmarked with the following indicators:

- Thermodynamics (actual energy used compared to the ideal process)
- Physical-thermodynamics (for given energy to tonne of production)
- Economics-thermodynamics (energy output to market price)
- Economics (money spent to money earned)
- Environment (energy produced to environmental impact)
- Descriptive (time series; weather impact)
- Factorial decomposition (activity effect, structural effect, intensity effect)
- Comprehensive approach (all energy used to demand indicators)
- Market based approach (energy consumed for controlled energy services)

The value of these indicators also represents the possibility of improvement in design, performance and setting up the measures to promote and monitor energy efficiency. It is worthwhile to aggregate these indicators for the overall energy efficiency of the system, plant or process.

Promoting Energy Conservation

Conservation saves energy and cuts cost. Energy conservation can be done at various levels of conversion, transmission and distribution, usage patterns, and habits of inhabitants. The present practice of charging higher unit price for higher consumption of electricity, by itself, did not have the desired effect. In the following paragraphs, (i) the major roadblocks and (ii) the possible options in effectively implementing energy conservation measures will be discussed.

Roadblocks

Efficient products often cost more than less efficient versions, especially when they are first introduced into the market. Unless consumers can verify the resulting savings, they may be reluctant to pay the additional costs. Or, as in many cases, they may simply be unaffordable. One good example is the replacement of incandescent bulbs with CFLs, especially in the economically challenged households. Most appliances and office and industrial equipment are not benchmarked. Energy-inefficient products are used because of their lower initial costs and government policies because the price they pay for the electricity is near zero and, hence, as economic principle would suggest the demand could reach infinity. That is, factory owners who have unauthorized electricity connections have no incentive for investing in energy-efficient equipment. The most glaring example is the use of local pumps for irrigation in areas or use of electricity for cooking where energy is either free or a fixed sum is paid irrespective of usage. Another issue is the lack of automation, especially in commercial and government establishments. Turning off unused appliances, electronic goods, and lights is neither always easy nor convenient.

Role of the City Government

How can the city government promote energy conservation? Some of the possible options for a city are:

- Implementing energy efficiency through the Energy Service Companies (ESCO). An ESCO is defined as a business that develops, installs, and finances projects designed to improve the energy efficiency and maintenance costs of facilities. The effectiveness of the ESCO experiences in Nasik and Bangalore can be followed by other cities also (Box 9.5).

Box 9.5

Energy Savings and Efficiency: Nasik and Bangalore Experiences

Jaisingh Dhumal, Archana Walia, and Mahesh Patankar

Nasik Municipal Corporation Street Lighting Project

ESCO concept

An Energy Service Company (ESCO) can be defined as 'a business that develops, installs, and finances projects designed to improve the energy efficiency and maintenance costs for facilities'. It is based on the concept of shared savings for financing energy efficiency measures. The ESCO acts as a project developer for a wide range of tasks and assumes the technical and performance risk associated with the project. The main problem in this approach is raising the required finances. Besides, the agreement for such projects involves 3 stakeholders namely, ESCO, end user and banks.

The Nasik Municipal Corporation (NMC) project is the first ESCO project to be implemented in Maharashtra on the concept of 'shared savings basis'. Based on its tender, Sahastratronic Controls Private Limited (SCPL), a company of the Sakar group was appointed by NMC as the ESCO where SCPL was the borrower to implement the project for upgrading the existing street lighting facilities on the end users' (NMC's) premises. NMC awarded the contract to SCPL for supply of 460 energy saving devices catering to almost half of the total requirement of NMC. Under the Energy Services Agreement (ESA), SCPL was required to invest on establishing energy efficiency measures, namely street light controllers (SLC), including capital assets, and maintain the same for a period of 5 years. Based on the ESA, ICICI Bank provided financial assistance of Rs 4.5 million to meet part of the cost of the project out of a Rs 20 million line of credit (LoC) facility sanctioned to the ESCO through USAID's ECO Programme. Repayments have been secured by means of a direct payment mechanism by NMC through an escrow arrangement.

Energy audit studies had estimated an energy savings potential of at least Rs 7.5 million per year. SCPL had guaranteed a minimum 25 per cent of energy savings. The project consisting of 361 panels with a total load of 4000 kVA was successfully commissioned in December 2004 to the satisfaction of NMC. Subsequent to the successful implementation of this project, NMC awarded the second ESCO contract to the ESCO for which ICICI Bank has sanctioned a rupee term loan of Rs 3.8 million out of the existing line of credit sanctioned.

Cost Benefit Analysis and Results

NMC draws about 5000 kW of energy per hour in a 12-hour day, through out the year for their street lighting application. This amounts to an energy bill of about Rs 5.5 million per month payable to MSEB (at a tariff of Rs 3 per kWhr) or an annual expenditure of around Rs 65 million on street lighting alone. For the purpose of the street lighting project, NMC had been split into 2 divisions with the division taken care by SCPL having an actual load of 2700 KW. On this basis the energy bill payable to MSEB for a 12-hour day worked out to Rs 35 million. On the basis of 25 per cent assured savings the savings for this area were estimated to be 0.25 ¥ 35 = 8.8 million. As against this estimate, the NMC project has till 31 December 2004 realized energy savings of about Rs 11 million over a period of 1 year on a total load of 4000 KVA and a capital investment of Rs 12 million. The average savings have worked to 11.0/35.0 = 31 per cent with peak savings on some sub-sections being as high as 44 per cent. SCPL has so far received Rs 7.8 million as its share of savings from NMC with corresponding NMC's share being Rs 3.2 million.

The project being the first of its kind in the country has served as a model for other ULBs/municipalities and government organizations to follow. Successful execution of the project and timely repayments to the bank have not only convinced other banks to lend to similar ESCOs but also encouraged other municipal corporations to undertake similar street lighting projects to yield significant savings from energy efficiency through the ESCO route.

There is no financial risk in entering into the contract for the municipal corporation, as the ESCO is the borrower. Moreover energy savings being substantial, the additional cash flows can be utilized by the municipal corporation for funding other priority schemes, such as health and education. The saved energy can be utilized by the utility either to improve power supply to rural areas and for new industrial development.

BESCOM Efficient Lighting Programme

The Bangalore Electricity Supply Company (BESCOM), with support from the Energy Conservation and Commercialization (ECO) project of USAID has implemented an innovative lighting initiative termed as the BESCOM Efficient Lighting Programme (BELP). This is a part of demand-side initiatives launched by BESCOM as a part of its larger goal of reducing system losses and providing opportunities to reduce the capacity increase targets. The project implementation was designed and guided by the International Institute of Energy Conservation (IIEC).

This unique residential lighting programme gives consumers an opportunity to replace energy intensive conventional lamps with energy efficient Compact Fluorescent Lamps (CFLs) in areas of high usage such as corridors, kitchen and portico. Every light replaced with a CFL will result in a saving of Rs 15 per month. This one of a kind programme will support energy conservation in the residential sector with an emphasis on protecting consumer interests—primarily that of product pricing and warranty servicing. BELP, a first of its kind in the utility-driven initiatives, BELP offers 1.3 million domestic consumers from the BESCOM Urban Circles to avail of BESCOM branded CFLs and 36 watts fluorescent tube lights from reputed customers selected through competitive bidding process that comprised of short-listing based on the technical merits and discounts offered to the consumers. Domestic consumers have an option to purchase lamps on:

- Direct sales at discounted prices
- Under installments (9 equal installments recovered through BESCOM monthly bills)

In both the cases, the consumers get a 12-month warranty backed up by BESCOM.

BESCOM initiated an innovative promotional campaign to promote energy efficient practices in the city in December 2004 along with:

- use of a unique hologram to identify BELP-supported products against other products
- leaflets circulated to the consumers in Bangalore Urban service territory
- display of posters, car stickers and leaflets at BESCOM billing and collection sections
- road shows of 5 days duration with suppliers' stalls operated at the sub-division offices
- communication to Residents' Welfare Association (RWA)

BELP involved suppliers, distributors, retailers, consumers and BESCOM as the stakeholders in the value chain. Benefits to the above stakeholders in the nature of reduced electricity consumption for consumers, lesser immediate impact on increased generating capacities for BESCOM and creation of higher market potential for manufacturers and suppliers are evident in this market transformation process. BESCOM and IIEC, during the implementation stage, targeted bringing up consumer awareness by educating them on benefits of efficient lighting and promoting right lighting sources for right applications. BELP was open to the consumers till middle of June 2005 and BESCOM, through its own initiative, is planning to extend this programme for an additional time period. As the learning from this pilot programme is quite essential for the success of DSM and energy conservation promotion among Indian utilities, IIEC and BESCOM have planned a detailed monitoring and evaluation (M&E) of this programme. M&E plan includes capturing the electricity savings for individual consumers based on a billing analysis comparing last one year's bills, capturing market take-up data for the CFLs sold in the Bangalore market and also to capture the consumers' perspectives through structured interviews to understand the drivers of the participants and views of the non-participating consumers. This analysis is ongoing and is expected to be completed by end of September 2005.

Note: Views expressed here are of the authors of the box.
Sources: ICICI Bank; IIEC; BESCOM

- Educating citizens about the economic benefits and methods of energy conservation. These messages can be transmitted through the media and NGOs.
- Encouraging the purchase of energy-efficient equipment. One method could be to persuade banks to provide loans under 'easier' conditions for such equipment.
- Promoting the construction of energy-efficient buildings.
- Actively promoting the use of energy-efficient appliances such as solar cookers and the use of solar heating, especially in B-class cities like Kanpur. The availability of electricity is low or very low in B or C class cities therefore promoting such concepts could lead to better living comfort.
- Ensuring that at least major energy consumers undertake regular energy audits.
- Requiring major energy consumers to commit to phased reduction in energy consumption.
- Reducing the demand for stolen electricity by making electricity available to consumers legally is a practical alternative. Improving access in the slums of Ahmedabad has reduced thefts substantially (Box 9.6).
- Promoting community participation for energy conservation. Since this a relatively new concept, it has been discussed separately.

The energy management plan (EMP) of the city of Phoenix, USA, clearly demonstrates the positive role that a city can play in energy management and the consequent 'spin-offs' (Box 9.7).

Community Participation for Energy Conservation

Looking at cities such as Kanpur, it appears[9] that their energy needs cannot be met, even in the distant future, by established utility companies. Even if adequate supply were available, the cost for setting-up the required infrastructure would be enormous. Because of the demand-deficit generators are omnipresent. Individual generators are not only expensive because of poor economies of scale, but also contribute significantly to pollution. To supplement existing power sources, community-based small power plants, powered preferably by CNG and biomass, or diesel generators can be set-up. Here community, for starters, could be industrial clusters or industrial parks and could later be extended to residential areas. Back-up power, primarily through diesel generators, is indeed a common sight in industries, residential

[9] Frequent power cuts, for long durations, have been common phenomena, especially in summer, in Kanpur.

Box 9.6

Reducing Theft by Improving Access: Ahmedabad Slum Electrification Project

David Foster

Electricity theft is a chronic problem in most Indian cities resulting not only in lost revenues but increases in accidental fires, electrocutions, power fluctuations, outages and ultimately even in threats to the sustainability of the utilities themselves. Furthermore, as much of the theft apparently involves complicity by utility employees and the police, no amount of inspection or increased police powers seem likely to curb this problem.

In analysing the problem of electric power theft, it is important to note that in India (where electric service is often denied in unrecognized slums) people purchase stolen electricity not so much with the hope of getting it at a lower price but simply because this is often the only way in which they can obtain such services. In fact, once the various bribes are included, people in these slum communities typically pay twice as much for stolen electricity as other residents pay for legal electricity.

Fortunately, the Ahmedabad Slum Electrification project clearly demonstrates that one of the most effective means of reducing electricity theft is not through increasing police powers but rather through reducing the demand for stolen electricity by making legal electricity a practical alternative.

In 2003 USAID initiated a catalytic effort to bring together the Ahmedabad Electric Corporation (AEC), the Ahmedabad Municipal Corporation (AMC), and several NGOs and slum communities. Following an agreement by the AMC to grant a moratorium on evictions and issue 'No Objection Certificates', the AEC, with the help of the NGOs, persuaded the residents to pay for legal connections and metres and to begin purchasing legal electricity instead of the stolen electricity that they had previously been paying for. SEWA and other NGOs played an important role in helping to win the confidence of slum residents and in some cases providing loans to pay for installation. As a consequence, not only were the slum residents able to obtain safer and more reliable electricity at approximately half of the earlier costs but the AEC saw an immediate drop in stolen electricity.

What began as a pilot project for 800 homes quickly spread city-wide and now more than 60,000 slum homes have been converted to safe legal electricity. Furthermore, as the residents are paying full cost with no subsidy from the city or the power company, AEC is rapidly extending this programme city-wide with no cost to the government.

This project is especially noteworthy for at least three reasons:

- it significantly improves the quality of life and productivity of the poor while demonstrating their 'willingness to pay' for good services;
- it provides a practical and efficient means for reducing theft of electric power; and
- it can be rapidly scaled up and is imminently sustainable because of the cost recovery and built in incentives for the major participants.

Note: Views expressed here are of the author of the box.

Box 9.7

The City of Phoenix Energy Management Programme

The City of Phoenix Energy Management Programme (EMP) began in 1978 with the underlying goal of eliminating inefficient energy use in government facilities in a cost-effective manner. The programme also aimed to promote renewable energy use, provide leadership in the community, and raise awareness of energy use among employees. Initial measures to reduce energy consumption were (i) no and (ii) low cost initiatives, such as the use of compact fluorescent lamps, and installing light switches in individual offices rather than using master switches. In 1983, a Savings Reinvestment Plan was adopted by the city to ensure future funding of the EMP. The plan requires that each year 50 per cent of documented energy savings be reinvested in additional energy efficiency improvements. As a result of the establishment of the Savings Reinvestment Plan, the EMP had money to spend on additional measures to improve energy efficiency. One important activity was the development of a strategy to maximize energy efficiency, which involved (1) energy audits of existing buildings and design advice for new construction, (2) installing/retrofitting the best and most appropriate technology and equipment, (3) combining energy efficiency with ongoing maintenance, and (4) promotion of state-of-the-art building management. Using the money from energy savings, the City of Phoenix has implemented over 1000 energy efficiency projects.

The Energy Management Plan has resulted in huge savings in electricity and natural gas use, with 1978–94 cumulative electricity savings of 246,106 MWh, and cumulative natural gas savings of 220,195 million cubic feet (MCF). These electricity and gas savings have resulted in the avoidance of 101,301 metric tonnes (MT) of CO_2 emissions (or 27,655 MTCE). For 1993–4, the EMP accounted for annual reductions of 36,769 MWh electricity, 32,898 MCF natural gas, and an estimated 15,195 MT of CO_2 (or 4150 MTCE). Additionally, the energy savings accounted for a reduction of approximately 65 MT of NO_x and 136 MT of SO_2. The electricity and gas savings also result in huge cost savings to the city. Annual energy costs have been reduced by about 10 per cent, equivalent to an estimated $4 million per year. One particularly successful measure is the overall lighting improvements, which alone are projected to account for US$4 million in savings over the first ten years.

complexes and entertainment centres. In fact, community-managed distribution and distributed generation can be a good business model. More importantly, community participation can be an effective tool for energy planning and governance.

Communities can play an important role in managing electricity supply. Residents can form an association and approach distribution companies for a 33 kV[10] power connection for bulk supply. This approach is becoming standard practice even in big hotels. In UP, power supply at 33 kV qualifies for a 7 per cent discount. In addition, these resident associations can also assist distribution companies in collecting bills and in the process negotiate a further discount in tariff. Money thus saved may be used to expedite maintenance and repair of faulty distribution hardware. Furthermore, installing and maintaining back-up generators for the whole community could generate economies of scale. Much like water harvesting, a village in Maharashtra shows that community initiatives in power generation can indeed yield rich dividends (Box 9.8).

Communities can also play a vital role in enforcing energy conservation measures and discipline among its members. An example is the policy in some residential complexes where generator connections are not provided to residents who have more than one air-conditioner in their flats[11]. In general communities can influence and provide advice on (i) construction of energy-efficient buildings, (ii) use of renewable such as solar heating, and (iii) energy conservation measures. Pressure can also be exerted on defaulters to pay their bills on time.

Per capita consumption of energy from fossil fuels compared to electrical sources is much less, but a large proportion of fossil fuel based energy is used by motorized personal transport. A city using an integrated transport can save not only fossil fuels but also reduce air pollution[12].

Integrated Transport

One major source of energy wastage in many cities is the absence of a mass urban transportation system. Many commuters are forced to use their personal vehicles, resulting in both fuel wastage and environmental pollution. A classic example is the city of Kanpur. A metre gauge railway line runs through the city from north to south. However, because of the limited number of local trains, commuters either travel in their cars or are forced to go on the polluting tempos. In any case, a lot has been written on the need for a mass urban transportation system and requires no further elaboration. What are of interest, though, are the proposed solutions. One option clearly is a rail transport system (RTS) operating in Delhi and Kolkata. The Delhi Metro Rail Corporation (DMRC) has already submitted the detailed project report (DPR) for Bangalore. To make an RTS successful, seamless integration with the bus system is essential. Because travelling by buses may not be a convenient option for a number of commuters, an elaborate parking system for 2- and 4-wheelers is a must near all rail stations.

Box 9.8

In Maharashtra Dark Zone, A Village Lights Up

Come sunset and residents of Nandurbar's Satpuda ranges, among Maharashtra's poorest swathes and unserved by the state's power grid, begin their sink into a deathly darkness. Exceptions being the 11 hamlets of Bilgaon, an idyllic village of 300-odd tribal families settled on the hillsides around the confluence Udhai and Titwi, two tributaries of the Narmada River. A 15-kilowatt hydel power project functional on Udhai's Bardhariya waterfall since January 2003 has provided electricity to every single home within 3-km radius of Bilgaon.

A check dam built across the Udhai river, is teamed with a channel on the right bank that directs the water into a 30,000-litre reservoir. From here the water gushes down a giant pipe and into the generation room where a turbine pump generates 15 kilowatts of power every day. This electricity is carried through electric wiring strung to a network of bamboo and wooden poles that criss-cross the hills of Bilgaon, leading into every single house. While Bangalore's Indian Institute of Science designed the turbine, Kerala's Peoples School of Energy drew up the blueprint, and AID funded the Rs 11 lakh project. This doesn't include the cost of labour, which the villagers volunteered entirely over nine months. A villager regulates the generation of electricity during a night shift for a monthly salary of Rs 400.

According to Anil Kumar who designed the project, 'It's the best model for such villages whose remote location makes them uneconomical consumers for the state.'

Source: Indian Express, 3 September 2005.

[10] Normal supply to a residential area is 11 kV

[11] This is an acceptable solution until enough electrical power is available on tap. The use of generator power in small towns and localities in large cities is expected to provide a bare minimum of power supply to households and commercial establishments to enable normal functioning—Editor.

[12] See Chapter 6 on Urban Transport which deals extensively with this.

Another option is to promote a bus-based mass rapid transit system, which Bangalore has targeted for 2010. Inspired by the model of cities like Curitiba in Brazil, the project focuses on infrastructure and planning issues along with the integration of public transport with traffic planning and management. As the Curitiba experience illustrates, transportation systems can serve as the backbone for the development and growth of a city in the future (Box 9.9). And hence the need to integrate urban transportation with a city's master plan is all the more pertinent.

Box 9.9

Efficient Transportation for Successful Urban Planning in Curitiba (Brazil)

Background

Due to agricultural mechanization from the 1950s to the 1980s, cities across Brazil experienced rapid growth with the migration of people from rural areas to urban areas. Curitiba, the capital city of the State of Paraná, experienced some of the highest growth in the country with population increases reaching an estimated 5.7 per cent a year during those decades. This uncontrolled increase in population presented circumstances that demanded effective city-planning in areas ranging from social services, housing and sanitation, to the environment and transportation. From the 1940s to the 1960s urban planners in Curitiba began the process of creating an urban Master Plan. Part of that plan included constructing a consolidated public transportation system to carry people easily throughout the metropolitan area and its surrounding municipalities.

The development of Curitiba's world-renowned transportation system began in the late 1960s, early 1970s. Unlike other Latin American cities at the time, Curitiba's planners decided to address the process of transportation as an integrative approach that could assist in the development of the city. In Curitiba's case, its planners recognized that transportation systems could serve as the backbone for the development and growth of the city in the future.

Instead of succumbing to the demand of the population and addressing transportation as a service that caters to an ever prevalent and pressing demand, they essentially planned their system with the intention of dictating the growth of the city. Curitiba decided to use buses as its primary means of public transport because it was not only the choice of transport in the past, it was also the most cost effective means of transport. To understand the integration of this famous system of transportation and the system itself, one would have to understand the history of Curitiba and recognize its foresight in urban planning that stems from a tradition of innovative planners.

Curitiba's Transportation System

The most significant changes in the transportation system were undertaken in 1974 with the creation of the road hierarchy and land control system (Rabinovitch and Hoehn 1995)[a]. In coordination with the Master Plan they began to construct the first two out of five arterial structural roads that would eventually form the structural growth corridors and dictate the growth pattern in the city. These structural corridors were composed of a triple road system with the central road having two restricted lanes dedicated to express buses.

Parallel to the express bus lanes were two local roads running in opposite directions. They allowed local traffic to pass through the city. In 1982, all five structural corridors were completed with inter-district and feeder lines. In accordance with these structural roads, zoning laws were set in place to structure the growth of the city. Large buildings holding a high density of people were permitted to be built along these corridors, but, as one moved away from these central corridors, the admissible densities declined from urban apartment buildings to residential neighbourhoods.

The Present System of Transportation

The transportation system is made up of three complementary levels of service that include the feeder lines, express lines and inter-district routes. The feeder lines pass through outlying neighbourhoods and make the system easily accessible to lower density areas. Sharing the roads with other vehicles, these feeder lines connect with the express system along the structural corridors. The express system then utilizes these dedicated bus lanes and transports large numbers of passengers to various locations along these structural corridors, thus operating much like a surface subway system. The inter-district routes allow passengers to connect to the axis of the express lines without entering the central city area.

The Integrated Transportation Network (ITN) encompasses transfer terminals, express routes, direct routes using boarding tubes, feeder and inter-district routes supplemented by central city routes, neighbourhood routes, night routes, special education routes, and pro-park routes which collectively make up Curitiba's Mass Transit System (MTS). Through carefully planned tube or terminal connections, passengers can pay one fare and travel throughout the system. To facilitate use of the system, passengers can identify a specific route by the colour and type of the bus used. The thirteen express lines that make up the express bus system for instance, operate on the structural corridors and are represented by large red articulated, bi-articulated or silver 'padron' buses.

Articulated and bi-articulated buses are large buses capable of carrying 170–270 passengers respectively and are joined in the centre by a pivot joint and flexible tubing that allows the bus to curve around turns without occupying more than one lane of traffic. Articulated buses have one joint and bi-articulated have at least two connected units. They are virtually like a train with connected cars. These buses connect the transfer terminals to the city centre. Passengers pay, enter and exit at tube stations.

The feeder routes are characterized by orange conventional buses that connect the terminals with the surrounding neighbourhoods. Inter-district routes use green padron or articulated buses that connect transfer terminals to different districts without passing through the centre of the city. The direct speedy routes are silver and use the tube stations along routes that link the main district and surrounding municipalities with Curitiba. Then there are Conventional Integration Radial Routes that are marked by yellow padron buses. They operate on the normal road network between the surrounding municipalities, the integration terminals, and the city centre. The City Circle Line is a fleet of white mini-buses that circle the major transport terminals and different points of interest in the downtown area. All school buses are marked with a yellow stripe and buses dedicated for the disabled are blue. The Integrated Transport System is made up of 340 routes that utilize 1902 buses to transport 1.9 million passengers per day. The entire network covers 1100 km of roads with 60 km of it dedicated for bus use. There are 25 transfer terminals within the system and 221 tube stations that all allow for pre-paid boarding. The Integrated System also has 28 routes and special buses dedicated to transporting special education and disabled patrons.

Solving the Fare Problem

With the evolution of the transportation system there increased a need for an effective mode of payment. Curitiba's city hall wanted to expedite bus service and recognized that one of the factors that generated delays is the hold-up in the mode of passenger payment. Over the years there have been many forms of payment implemented. A new system to avoid delays was created in which the city eliminated transfer payments and substituted them with transfer tokens made of paper. But after 7 months of implementation, the city discovered major forgery of the paper transfers. The city then tried to install a two-fare payment, separating the express fares from the feeder fares (fares for the outlying buses connecting to those going to the city centre). This system was repealed after one and a half-years because it favoured the rich who resided closer to the centre and paid only one fare over the poorer population who resided on the periphery of the city and would have to pay two passages to arrive in the centre.

Realizing the social imbalance imposed by this fare mode, the city dropped the feeder fare and allowed passengers to ride the feeder buses for free. After a while the city received public complaints about the unsanitary conditions on the feeder buses. They became sleeping places for the homeless and bus drivers refused to drive these buses. The city then decided to return to the one fare method and built fences between stops for the express and feeder buses. This method proved to be successful until they became overcrowded. They became unsanitary and were often referred to as 'pig stalls.'

In 1980, the city finally developed and constructed transfer terminals that operated like subway stations. The terminals, constructed with telephone accessibility, attracted newsstands and flower shops and became aesthetically attractive and user friendly.

It was also at this time that the city introduced automatic ticketing to the system. This form of payment allowed passengers to purchase metal tokens at terminals, newsstands or shops, or pay with money at the bus terminals. They hoped to increase the speed of transfers and boarding of passengers which would expedite bus circulation. The city believed that under careful planning of transfers, passengers could travel throughout the system for only one fare. Despite the fare issues, the city had to deal with the overwhelming attraction of the express system. Upon its implementation in 1974, its novelty and popularity resulted in overcrowded buses that caused delays in boarding at stops and terminals. To compensate for the loss in time, bus drivers would increase speed, creating potentially dangerous situations and accidents. The city found it necessary to implement speed control monitors, create boarding tubes and tailor bus designs to accommodate the growing demand.

The city also had to create a system in which individual bus companies that catered to the various zones in the city could share revenues without competing with each other. Traditionally the city was partitioned in different zones that were serviced by individual bus companies. But, with the creation of the inter-district routes and the implementation of the Integrated Transportation Network along with the unified fare, passengers could pay one company at a terminal located in a particular zone and ride the system without paying the other bus companies. In 1987 the city addressed this problem by distributing transportation revenue based on the number of kilometres travelled by vehicle type for any given company. With each company given a number of route kilometres and a timetable, each company competes with the schedule not with other companies.

Bus and Station Design

After the construction of terminals and the implementation of the unified fare, the city wanted to develop buses and stations designed with the intention of avoiding fare evaders. For this reason, buses are designed with three doors, two doors for exiting and a front door for boarding. In a category by itself, these urban buses are constructed with turbo engines, lower floor levels, wider doors, and a convenient design for mass transit. Curitiba also developed boarding tube stations that were placed along direct routes and express lanes. To increase convenience, boarding efficiency and reduce fare evaders the tubes elevate passengers to the bus platform level where automatic doors operated by the tube conductor open parallel to the bus doors. Passengers pay an entrance fare at the turnstile and wait for their respective direct or express bus to pass. Disembarking passengers leave the stations through a direct exit. To further assist passengers, each tube station is equipped with station and route maps and with small lifts situated beside the entrance of the tube to help disabled passengers, strollers, and passengers carrying heavy bags enter the tubes with agility.

Note: [a]J. Rabinovitch and J. Hoehn (1995). 'A Sustainable Urban Transportation System: The Surface Metro in Curitiba, Brazil', The Environmental and Natural Resources Policy and Training Project, Michigan State University, Michigan.
Source: http://www.solutions-site.org/artman/publish/article_62.shtml

Environment

Consumption of energy affects urban environment predominantly in three ways: (i) pollution due to vehicular exhausts, (ii) use of diesel generator sets, and (iii) indoor pollution. The issue of pollution caused by vehicles and diesel-generator sets has already been dealt with in the previous sections of the report. Impact of predominantly indoor living on health is not much appreciated. According to the CPCB, health problems arising out of indoor air pollution are wide spread because of the following reasons:

- An indoor pollutant is one thousand times more likely to reach the lungs as compared to outdoor pollutant.
- More and more people in urban areas are compelled to spend major part of their time indoors.

Women, children and the aged are most vulnerable to indoor pollutants and likely to suffer health related problems. Indoor pollution is primarily a problem with the urban poor, who use firewood, kerosene and coal for cooking especially in class III to IV cities and towns. Firewood and chips (22 per cent), kerosene (22 per cent) and LPG (44 per cent) are the important sources of energy used for cooking in the urban sector. These fuels emit toxic pollutants like carbon monoxide, particulates, and hydrocarbons. Here women work in smoky poorly ventilated kitchens with children beside them. The smoke emitted by badly designed stoves that use wood, dung cakes and agriculture waste leads to acute respiratory, lung and eye diseases among both women and children. A smoky kitchen could affect expecting mothers as it could lead to stillbirths or low birth weight babies. Indoor pollution is a problem to reckon with[13]. The increasing use of LPG as cooking fuel is going to reduce indoor air pollution. There has been an increase of about fifteen percentage points in households using LPG and a decrease of 8 per cent in the use of firewood/chips since 1993–4.

Conclusion

There is little doubt that Indian cities can do with better energy management. Many real life illustrations have been provided which can be used by individuals, commercial organizations and city administrators to formulate a long-term vision for urban energy management.

To meet energy needs in an economical fashion community based models hold the key by solving integration issues between various technologies for generating useful energy. Energy service organizations must be encouraged to promote entrepreneurial activities through energy trusts. The communities in this model become bulk consumers. They get concessions in purchase of energy, which can be routed to provide energy services and promote energy efficiency at various levels. Awareness programmes are required to reduce leakage of electricity. Government should assist energy companies in recovering their dues, especially in post-paid connections, for example in electricity and piped natural gas in the future.

Energy master plan (EMP) of a city must be integrated through city civil master plan so that the problems arising out of expansion of a city and its activities are minimized. An EMP should be openly debated through public meetings, workshops and the media. An emergency plan along with an EMP should also be prepared for prioritizing energy delivery in the event of a shortage.

[13] *http://www.indiatogether.org/2004/nov/chi-hazards.htm*