4.1 INTRODUCTION

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 is critical, and will be the focus of this Unit. The fundamental goal of energy management is to produce goods and provide services with the least cost and least environmental effect. The term energy management can be understood by “The strategy of adjusting and optimizing energy, using systems and procedures so as to reduce energy requirements per unit of output while holding constant or reducing total costs of producing the output from these systems”. The objective of Energy Management is to achieve and maintain optimum energy procurement and utilization, throughout the organization and to minimize energy costs/waste without affecting production and quality; and minimize environmental effects.

After reading this unit you will be able to:

- Define energy and establish relationship between energy management and development
- Explain various components of energy management
- Analyse urban energy status and energy issues
- Discuss the necessity of urban sustainable energy planning
- Discuss the challenges of urban energy management system

4.2 ENERGY CONCEPTS AND TYPES

Energy is the ability to do work. Energy is the capacity of a physical system to perform work. Energy exists in several forms such as heat, kinetic or mechanical
energy, light, potential energy, electrical, or other forms. So energy is power, without which nothing can survive on Earth. The term, energy, used here, has a slightly different meaning. Energy actually means, useful energy, or, the energy that we can use; for cooking, operating machines, to run vehicles, and so on. And we get this useful energy only from specific sources, which we call, sources of energy. A good source of energy should have the following characteristics.

- It should do a large amount of work per unit mass or volume. This means that the output energy must be more than the input energy. It should have high calorific value.
- It should be easily accessible. The energy source should be able to provide energy over a long period of time. Examples: coal and petroleum.
- It should be easy to store and transport. The most common sources of energy such as coal, petrol, and LPG need to be transported to users from their points of production. They also need safe and economical storage and transportability. Safe and convenient to use. Energy sources should be safe as they are used by a large number of people, and they should be convenient. Example: nuclear energy from a nuclear power plant is too hazardous to be used at homes.

**Types of Energy**

Broadly, there are two types of energy: i) conventional energy ii) non-conventional energy.

i) **Conventional sources of energy:**

Conventional sources of energy include fossil fuels, thermal energy and hydroelectric energy. Fossil fuels include fuels that are most commonly used, such as wood, coal, and petroleum. These fossil fuels are non-renewable sources of energy and we need to conserve them.

**Wood**

Wood is a major source of energy for man; it is widely used for cooking and heating. It is a primary fuel which can be used directly to produce heat. A major portion of heat produced by burning wood is lost to the surroundings and only 8 per cent of the total heat is actually used for cooking food, leading to significant wastage of fuel. It produces a lot of smoke due to incomplete combustion, which leads to pollution and health hazards.

**Coal**

Coal varies in quality according to the amount of pressure and heat to which it is subjected to during its formation. It consists largely of carbon, hydrogen, oxygen, and small amounts of sulphur and nitrogen. Coal is formed in layers called seams and takes millions of years to be formed. The oxides of carbon, nitrogen and sulphur are acidic oxides, and are released when coal and petroleum are burned. This leads to acid rain which affects our water and soil resources.

Non-renewable resources of energy in India are the natural resources of energy that cannot be produced, regenerated, re-grown, or reused on a large scale. These non-renewable resources exist in a fixed amount and are consumed much faster than nature can recreate them. Fossil fuels including
coal, petroleum, and natural gas are some examples of non renewable resources of energy in India. On the other hand, resources such as timber, which can be recycled, are known as the renewable resources of energy in India. A non renewable resource is always strained down with anabolic procedures that use up energy.

Non renewable resources of energy in India such as coal, petroleum, oil and natural gas require millions of years to form naturally and cannot be replaced as quickly as they can be consumed. Eventually natural resources will become too costly to reap, and mankind will have to find other sources of energy. At present, the main sources of energy used in India are non renewable sources of energy.

ii) Non-conventional sources energy

Non conventional sources of energy include wind, tides, solar geo-thermal heat, and biomass including farm and animal waste, as well as human excreta. All of these sources are renewable or inexhaustible. They are inexpensive in nature.

**Wind Energy**

It can be used for pumping water, a prime need in irrigating farms in the countryside. Also, it can be used for generating electricity. The states of Gujarat, Tamil Nadu, Maharashtra, and Orissa are better places in regard to this energy. Areas with constant and high speed winds are suitable for the purpose. Besides windmills, there are also wind farms.

**Tidal Energy**

This is another unlimited and inexhaustible source of energy. The Gulfs of Kutch and Cambay are ideally suited to develop electricity from the energy produced by high tides entering into narrow creeks.

**Solar Energy**

The most abundant and inexhaustible source of energy is the sun. It is a universal source and has huge potential. A notable achievement has been the invention of solar cookers. They help in cooking food almost without any cost. Small and medium sized solar power stations are being planned for deployment in rural areas. The successful applications of the solar energy, so far, have been for cooking, heating water, water desalination, space heating, and crop drying. It is going to be the energy of the future when fossil fuels, namely coal and oil, are totally exhausted.

**Thermal Energy**

India is not rich in this source. However, efforts are on to utilize natural energy from the hot springs at Manikaran in Himachal Pradesh. Energy so produced can be used for running cold storage plants.

**Biomass**

The efforts are being made in India to make use of biomass in an efficient and scientific manner. The two main components of the biomass programme are production and utilization of biomass.
Energy Plantation
Waste and denuded lands are being used for plantation of fast growing shrubs and trees with high calorific value. These, in turn, provide fuel wood, charcoal, fodder, power, and also scope for rural employment. Through the gasification system, these energy plantations over 8,000 hectares were producing nearly 1.5 MW of power, annually.

Energy from Urban Waste
A pilot plant for demonstration purposes has already been set up in Delhi to treat solid municipal waste for conversion into energy. It produces nearly 4 MW of energy every year. Sewage in cities is used for generating gas and electricity.

Biogas Based Power Plants
It is estimated that sugar mills in India can generate 2,000 MW of surplus electricity during crushing season. Out of every 10 MW of energy produced by a mill of a given size, 4 mw would meet its own power requirements and the rest, 6 MW of energy, can be utilized to irrigate fields by feeding it into the local grid. Like biogas, several other farm wastes such as rice husks are also being used to produce electricity.

Farm, Animal, and Human Wastes
By using farm and animal wastes as well as human excreta, *gobar gas* plants are being set up in villages to make them self sufficient in their power requirements. The power so produced, is used for cooking, lighting homes and streets, and meeting the irrigation needs of villages. The plants are being set up both at individual, community, and village levels. Sewage from large cities can be used for generating biogas.

### 4.3 SUSTAINABLE URBAN ENERGY PLANNING

Sustainable urban energy planning integrates sustainable energy, clean energy technologies and responsible resources management strategies for the development of economically, socially and environmentally healthy communities. The ultimate aim is to bring about a paradigm shift with respect to energy and resource use within all of the functions of a community and to change infrastructure parameters and development patterns by affecting ‘how and where we build’ and ‘how we generate, deliver and use energy’.

Sustainable energy planning seeks to strike a new balance in the dynamics between energy and resource supply and demand, by fusing energy and resource efficiency with smart growth, smart grid, intelligent transportation system management and similar urban strategies within the following framework of community planning and design principles:

#### 4.3.1 Sustainable Use of Energy Resources
Planning and design should maximize the efficient use of energy resources across all end uses, while minimizing direct and indirect adverse impacts on the environment.
4.3.2 Ecological Community Form and Function

Planning and design should emulate nature to maximize the benefit of natural systems and preserve and restore the natural environment. Urban functions should be managed to reinforce natural flows and characteristics, creating a balance and mutually supportive cycle of interaction between built and natural environments.

4.3.3 Environmentally Sound and Energy Efficient Land Use Optimization

Planning and design should seek to minimize the consumption of energy, material and natural resources by restructuring and more efficiently utilizing the existing urban footprint. In addition, compact, mixed-use development, along with the co-location of compatible uses and increasing proximate loads, can enable cost-effective distributed energy resource applications and urban mass transit systems.

Potential for Low Carbon Urban Growth in India

McKinsey (2010) reports that over 75% of urban India is still to be built/re-built. The same report also suggests that if India’s cities systematically plan for higher densities around business districts, together with transit corridors and other supporting infrastructure, India can save up to 6.2 million hectares of land, which in itself is a critical component of low carbon development.

4.3.4 Energy and Environmental Technology Integration

Planning and design should integrate cleaner energy systems into development projects, using ‘whole building’ and ‘community-scale’ approaches to maximize energy performance and economic value, while minimizing adverse environmental impacts. Efforts should capitalize upon technology advancements, but promote integrated technical systems needed to expand the use of local renewable and recyclable energy resources, build sustainable local and regional energy networks, secure underground distribution systems for critical urban facilities, develop supply and demand network control systems, and establish more technology-ready infrastructure.

4.3.5 Community Resources Management

Wherever possible, planning and design should engage community residents in the efficient use of energy and material resources by decentralizing resource management systems to the neighbourhood level. Neighbourhood-based systems should be designed to provide ongoing systemic management of community resources and promote shared energy resources and material and process efficiencies, based on town energy management plans.

4.3.6 Social Equity and Economic Vitality

Energy-efficient planning and design should increase access to affordable housing, public services and employment for lower-income populations and stimulate local economic opportunities.

There is a fundamental linkage between energy and community form. The value proposition for integrating energy planning into urban land-use and design and for taking a systems approach to community development lies in the fact that
70% of a community’s energy consumption is influenced by land use allocations, site design, development practices and transportation and utility infrastructure. Indeed, realizing the fuller potential of energy efficiency and renewable energy is dependent to a large extent on the form and parameters of a community’s infrastructure and built environment. Therefore, to maximize GHG emissions reductions and energy savings, the effects of land use decisions and urbanization need to be addressed and mitigated. Moreover, the opportunity to influence significantly local energy end-use through ‘how and where’ construction and renovation takes place is quite promising. manifest

By taking a ‘total energy and environmental systems’ approach to land-use development and urban design, sustainable urban energy planning seeks to reconcile environmentally sound energy and resource use with exponential urban growth. Sustainable energy planning integrates energy and environmental planning into land-use, transportation and economic development planning to support community sustainability. Through these linkages, sustainable energy planning seeks to promote the efficient production, delivery and use of energy resources in the development of economically, socially and environmentally healthy communities.

This planning, therefore, takes an holistic approach to sectors such as transport, waste, water and energy, that have traditionally been addressed in a disparate manner, in order to better characterize future energy demand, optimize energy use and influence supply strategies. This systems methodology enhances individual technology, facility and sector approaches. Moreover, sustainable energy planning can guide the development and use of distributed energy resources within communities to assure responsible resources management “that meets present needs without compromising the ability of future generations to meet their needs. (Brundtland Commission, 1987)”

Generally, sustainable development organizations have focused on improving the natural and built environment by reducing sprawl, enhancing livability, improving environmental quality and reintroducing traditional neighbourhood development patterns (smart growth). For their part, globally, sustainable energy organizations have focused upon achieving environmental and other benefits through distributed energy projects (combined cooling, heat and power; demand side management, distributed generation, district energy) that introduce renewable energy and energy efficiency in buildings, transportation systems, industrial and commercial processes and municipal infrastructure. Sustainable energy planning expands upon and integrates these areas of focus to create commercially viable and transferable models of development that integrate energy resources and technologies with community design for long-term community sustainability.

However, there also are significant obstacles to sustainable energy planning by local governments. Primary among these are significant financial constraints, competing priorities, lack of knowledge and technical expertise, little incentive to undertake energy-related activities outside of managing their own consumption; lack of control of the resources required to engage in comprehensive energy sustainability planning and regulatory obstacles. It is also a daunting challenge to integrate energy systems planning into local land use planning and development processes that have been structured to address other matters such as growth management, public infrastructure development (transportation, water supply and wastewater treatment, and solid waste management), affordable housing, etc.
Zero net energy (ZNE) refers to a building or development with a net energy consumption of zero over a typical year. To cope with fluctuations in demand, zero energy buildings or developments are typically envisioned as connected to the grid, exporting electricity to the grid when there is a surplus, and drawing electricity when not enough electricity is being produced. The amount of energy provided by on-site renewable energy sources is equal to the amount of energy used by the building or development. A ZNE building or development may also consider embodied energy – the quantity of energy required to manufacture and supply to the point of use the materials utilized for its building.

4.4 LOCAL GOVERNMENTS AND SUSTAINABLE ENERGY MANAGEMENT

There are compelling reasons for local governments to become involved in sustainable urban energy planning. Smarter energy use can reduce energy costs, improve public health and safety, enhance economic development and environmental quality, increase social equity and environmental justice, and raise living standards and the overall quality of life. With the increasing availability of energy supply and end-use technologies, local governments also are seeking to achieve a higher level of control and self-sufficiency with respect to their access to energy resources. To date, local governments have engaged in sustainable energy planning in three principal ways:

- Reducing energy consumption within their own facilities and operations;
- Promoting efficient energy use and alternative resources in the private sector through judicious use of incentives, regulations and demonstration projects; and
- Shaping local land use and development patterns to reduce per capita energy use and improve environmental quality.

Such efforts have largely been undertaken separately rather than in an interrelated and systemic manner. Furthermore, the efforts have been predominantly project-oriented, aimed at addressing the environmental impacts of energy use in stationary and mobile sources by increasing efficiencies within buildings, installing alternative energy in municipal facilities and fleets, and promoting mass transit and alternative mobility options. But these efforts have not been guided or prioritized by strategic energy planning that seeks to address future growth and uncertainties and to assess a broad range of options based upon systemic community evaluations.

To contribute to a future of both population growth and urban sustainability, local and regional governmental officials must better understand:

- How different development patterns, building and infrastructure design and materials, and clean energy technologies can increase energy and resource efficiency without compromising the quality of life;
- How decisions regarding private development projects affect long-term energy demand;
- How energy smart planning carried out as part of land use development and growth management processes can bring into better balance energy supply with demand, including by facilitating the orderly, capital efficient and...
environmentally sound application of distributed energy resources. Developing the capacity for sustainable energy planning would enable local and regional governments to:

- Shape energy and resource-efficient community development patterns and land-use practices under the discipline of a sustainable urban form, significantly reducing energy consumption and greenhouse gas emissions, while also enhancing energy reliability and security and economic growth and development;

- Advance a ‘systems’ approach for integrating and optimizing clean energy technologies within development projects to accelerate the combined use of renewable energy and advanced end-use and smart grid enabling technologies within a community’s built-environment and infrastructure; and

- Help design market-changing public-private partnerships, policies, and business and financial models to overcome technical, market and institutional barriers to clean energy products, services and infrastructure.

Not many urban local bodies (ULBs) in India are oriented towards sustainable energy planning; a few ULBs have undertaken initiatives as illustration in case studies below.

### Energy Efficiency Cell – Surat Municipal Corporation

**Mission:**
- To optimise the specific energy consumption required to provide various services without affecting quantity and quality.

**Functions:**
- To conduct in house Energy Audit
- To conduct External Energy Audit
- To identify energy conservation projects and its feasibility
- To find out sources for procuring power at lowest possible price
- Feasibility study for own power generation from conventional & renewable energy sources
- To do scrutiny of file having more than equal to 30 kW power loading.
- To monitor the usages of electricity of entire corporation

### Reducing Theft by Improving Access: Demand Side Management – Case of Ahmedabad

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 Ahmadabad 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 Ahmadabad Electric Corporation (AEC), the Ahmadabad 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 (i) it significantly improves the quality of life and productivity of the poor while demonstrating their ‘willingness to pay’ for good services; (ii) it provides a practical and efficient means for reducing theft of electric power; and (iii) it can be rapidly scaled up and is imminently sustainable because of the cost recovery and built in incentives for the major participants.

Source: India Infrastructure Report, 2006

4.5 ROLE OF INFORMATION TECHNOLOGY

Integral to this planning is the development and application of modelling and analytical tools that can assess what changes are needed to foster energy and resource efficient community development, as well as to inform the structuring of public-private partnership arrangements to evaluate and implement cost-effective options. Effective decision support tools and methods are needed to:

- Assess systematically the costs and benefits of alternative urban design and site planning scenarios;
- Enable city officials, development authorities and planners to formulate municipality-wide energy management plans that consider all energy sources and all end-uses; and
- Structure and fund effective energy and environment-related programs, measures and partnerships to overcome technical, institutional, financial and other barriers to sustainable development.
In this section, you have read about sustainable urban energy planning local governments and sustainable energy management and role of information technology. Now, answer the questions given in Check Your Progress 1.

Check Your Progress 1

Note: a) Write your answer in the space given below
   b) Compare your answer with those given at the end of the unit.

1) What are the key principles of Sustainable Urban Energy Planning?

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2) What do you understand by ‘Zero Net Energy’?

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4.6 ENERGY AUDIT

4.6.1 Types and Methodology

Energy Audit is the key to a systematic approach for decision-making in the area of energy management. It attempts to balance the total energy inputs with its use, and serves to identify all the energy streams in a facility. It quantifies energy usage according to its discrete functions. Industrial energy audit is an effective tool in defining and pursuing comprehensive energy management programme.

As per the Energy Conservation Act, 2001, Energy Audit is defined as “the verification, monitoring and analysis of use of energy including submission of technical report containing recommendations for improving energy efficiency with cost benefit analysis and an action plan to reduce energy consumption”.

4.6.2 Need

Energy audit helps understand more about the ways energy and fuel are used in ULB functioning, and helps in identifying the areas where waste can occur and where scope for improvements exist.

Energy audit gives a positive orientation to the energy cost reduction, preventive maintenance and quality control programmes which are vital in ULB functioning. It helps keep focus on variations which occur in the energy costs, availability and reliability of supply of energy, decide on appropriate energy mix, identify energy conservation technologies, retrofit for energy conservation equipment etc.

In general, energy audit is the translation of conservation ideas into realities, by lending technically feasible solutions with economic and other organizational considerations within a specified time frame.

The primary objective of Energy Audit is to determine ways to reduce energy consumption per unit of product output or to lower operating costs. Energy Audit provides a benchmark for managing energy in the organization and also provides the basis for planning a more effective use of energy throughout the ULB’s jurisdiction.

4.6.3 Types of Energy Audit

The type of Energy Audit to be performed depends on:

- Function and type of industry;
- Depth to which final audit is needed; and
- Potential and magnitude of cost reduction desired.

Thus Energy Audit can be classified into the following two types.

i) Preliminary audit.

ii) Detailed audit.

4.6.4 Preliminary Energy Audit Methodology

Preliminary energy audit is a relatively quick exercise to achieve the following and uses existing, or easily obtainable data:

- Establish energy consumption in all ULB assets (buildings, water supply, sanitation, solid waste management, streetlighting, etc.);
- Estimate the scope for saving;
- Identify the most likely (and the easiest areas) for attention;
- Identify immediate (especially no-/low-cost) improvements/savings;
- Set a reference point that the ULB may want to achieve; and
- Identify areas for more detailed study/measurement.

4.6.5 Detailed Energy Audit Methodology

A comprehensive audit provides a detailed energy project implementation plan for a facility, since it evaluates all major energy using systems. This type of audit offers the most accurate estimate of energy savings and cost. It considers the
interactive effects of all projects, accounts for the energy use of all major equipment, and includes detailed energy cost saving calculations and project cost.

In a comprehensive audit, one of the key elements is the energy balance. This is based on an inventory of energy using systems, assumptions of current operating conditions and calculations of energy use. This estimated use is then compared to utility bill charges.

Detailed energy auditing is carried out in three phases:

- **Phase I - Pre Audit Phase**
- **Phase II - Audit Phase**
- **Phase III - Post Audit Phase**

**Phase I - Pre Audit Phase Activities**

A structured methodology to carry out an energy audit is necessary for efficient working. An initial study of ULB assets targeted should always be carried out, as the planning of the procedures necessary for an audit is most important.

i) **Initial Site Visit and Preparation Required for Detailed Auditing**

An initial site visit may take one day and gives the Energy Auditor/Engineer an opportunity to meet the personnel concerned, to familiarize him with the site and to assess the procedures necessary to carry out the energy audit.

During the initial site visit the Energy Auditor/Engineer should (i) discuss with the site’s senior management the aims of the energy audit; (ii) discuss economic guidelines associated with the recommendations of the audit; (iii) analyse the major energy consumption data with the relevant personnel; (iv) obtain site drawings where available - building layout, steam distribution, compressed air distribution, electricity distribution etc.; and (v) tour the site accompanied by team members and concerned engineers.

The main aims of this visit will be to (i) finalise Energy Audit team; (ii) identify the main energy consuming areas/plant items to be surveyed during the audit; (iii) identify any existing instrumentation/ additional metering required; (iv) decide whether any meters will have to be installed prior to the audit eg. kWh, steam, oil or gas meters; (v) identify the instrumentation required for carrying out the audit; (vi) plan with time frame, (vii) collect macro data on plant energy resources, major energy consuming centres; and (viii) create awareness among stakeholders.

**Phase II: Detailed Energy Audit Activities**

Depending on the nature and complexity of the site, a comprehensive audit can take from several weeks to several months to complete. Detailed studies to establish, and investigate, energy and material balances for specific plant departments or items of process equipment are carried out. Whenever possible, checks of plant operations are carried out over extended periods of time, at nights and at weekends as well as during normal daytime working hours, to ensure that nothing is overlooked.

The audit report should include a description of energy inputs and product outputs by major department or by major processing function, and evaluates the efficiency
of each process. Means of improving these efficiencies need to be listed, and at least a preliminary assessment of the cost of the improvements will be made to indicate the expected payback on any capital investment needed. The audit report should conclude with specific recommendations for detailed engineering studies and feasibility analyses, which must then be performed to justify the implementation of those conservation measures that require investments.

The information to be collected during the detailed audit includes (i) energy consumption by type of energy, by department, by major items of process equipment, by end-use; (ii) material balance data (raw materials, intermediate and final products, recycled materials, use of scrap or waste products, production of by-products for re-use, etc.); (iii) energy cost and tariff data; (iv) process and material flow diagrams; (v) generation and distribution of site services; (vi) sources of energy supply (e.g. electricity from the grid or self-generation); (vii) potential for fuel substitution, process modifications, and the use of co-generation systems; and (viii) energy Management procedures and energy awareness training programs within the ULB.

Existing baseline information and reports are useful to get consumption pattern, production cost and productivity levels. The audit team should collect data concerning (i) technology, processes used and equipment details, (ii) capacity utilisation, (iii) amount & type of input materials used, (iv) water consumption, (v) fuel consumption, (vi) electrical energy consumption, etc., (vii) quantity and type of wastes generated, (viii) efficiencies/yield, among others.

Based on the above, a series of energy conservation opportunities are identified. Based on a financial and economic viability (internal rate of return, net present value, economic rate of return are common tools), these opportunities are listed under low cost-high return, medium cost-medium return, and high cost-high return matrix based on which these are in turn graded into short term, medium term, and long term activities. The report is then presented to the senior decision makers from the ULB for approval.

**Phase-III: Post-Audit Activities**

This phase primarily includes implementation and follow-up of the approved activities.

### 4.7 GOVERNMENT RESPONSE – MUNICIPAL DEMAND SIDE MANAGEMENT

BEE has developed a module for determining municipal demand side management, as well as a manual for development of municipal energy efficiency projects. Both are accessible on the BEE website. The Manual indicates that all ULBs should undertake self-assessment (preliminary audit) based on whose findings the detailed audit can be contracted out or structured on a public-private partnership (PPP) modality.

#### 4.7.1 Guidelines for Self-Assessment

The BEE Manual indicates that a ULB should do a self-assessment in order to evaluate the importance of the project. This assessment includes the reasons and goals for the project, a feasibility study, analysis of the project financing and
contractor selection options. Thereafter, an energy efficiency (EE) project plan needs to be prepared by the ULB. The commitment of the municipality and a well-defined EE project plan can highly impact the success of the EE project.

4.7.2 Energy Service Company (ESCO)

ESCO is a company with technical expertise that enters into a performance contract with the ULB to implement energy efficiency measures that optimize energy usage and reduce energy expenditure in a technically and commercially viable manner. ESCO contracts differ from typical service or supply of equipment contract that the municipality is familiar and accustomed to. Around the world, ESCO contracts are considered as viable business model for financing and implementing energy efficiency projects.

The ULB can enter into an Energy Performance Contract (EPC) to initiate investment grade energy audit and implementation of commercially feasible energy efficiency measures that offer attractive returns in the form of reduced operating costs due to optimized energy usage and reduced energy expenditure and improved delivery of services. The project can be financed by the Municipality or the ESCO. The contract may have rewards and penalties built into it in the form of explicit or implicit guarantees. The Municipality may engage the service of an ESCO in a single step or a two step process. In the single step process the ESCO does the IGA and effect energy savings by implementing recommended measures. In the two steps process the municipality first contracts with an ESCO to do an IGA and based on the audit report prioritize measures by calculating the time, capital investment and payback period and proceed with implementation.

4.7.3 Guidelines for Procuring Services for Undertaking a Detailed Audit

BEE prescribes that preferably a ULB should outsource the work of carrying out the detailed energy audit after undertaking a preliminary audit based on which EE options are prioritised. As indicated earlier, the ULB has a range of options on engaging the private sector on delivery of the EE options.

A) Steering Committee

The municipality should establish a steering committee to assist in monitoring the work of the ESCO/consultant and render guidance for the entire project work. The team leader from the ESCO can then meet with the committee on a weekly or biweekly basis to review progress to facilitate the completion of the project in a timely manner and eliminate discrepancies at later stages.

B) List proposed efficiency measures

The detailed energy audit carried out at the various facilities will help identify energy efficiency measures. The measures that have the best technical and economic potential will be further developed into saving projects that should be listed in the report.

C) Develop a set of potential energy efficiency (EE) projects

The ESCO develops a set of potential efficiency projects for consideration, in consultation with the steering committee. An investment grade evaluation conducted on each that includes the following:
Urban Infrastructure-I

- Description of the baseline situation (e.g., losses from a water supply system)
- Project design, including basic engineering
- Technical constraint analysis
- Project financials
- Baseline calculation
- Options for monitoring and verification
- Assessment of potential technical and financial risk and a risk mitigation plan

The baseline of energy use (and water as appropriate) is calculated from all relevant information, such as operating conditions, measurements of various system equipment, log book trends, historical data, and any previous test reports on the existing operating conditions. The project financials (cost benefit and financial analysis) are calculated by the ESCO using the detailed cost estimates obtained for all equipment and the projected saving rates. This allows the potential projects to be classified according to their cost-effectiveness. Cash flow considerations should also be taken into account since this will determine the amount that needs to be financed by a commercial bank or other local/international financial institutions. From the financial analysis, the ESCO develops an action plan by prioritizing the projects based on so called “ABC-analysis” where activities are classified according to specific performance criteria, both technical and financial. “A” corresponds to priority projects; “B” corresponds to less important projects; and “C” classifies relatively unimportant ones.

D) Monitoring and Verification

Monitoring and verification involves the measurement of parameters in accordance with standard engineering protocols, codes & practices, at a predefined periodicity and term. M&V on efficiency projects are to be conducted in accordance with the norms of the international performance measurement and verification protocol, and considering operating conditions specific to the country. Various M&V plans consistent with IPMVP should be analyzed to select the best option for tracking savings. Since savings are calculated relative to the baseline, the choice of M&V protocol needs to be consistent with the calculation of the baseline. As needed, different M&V protocols may be chosen for different individual projects.

E) Preparing the Audit Report

The audit report will include the following:

- Executive summary - provides brief description of the systems and facilities covered overview of the existing conditions, measures evaluated analysis methodology, results and a summary table presenting the cost and savings estimates for each recommended measure. It also includes a summary of the recommended measures and costs as well as the financial indicators of the project.

- Background - extensive background about the municipality and project should be provided.
• Facility description - Details of the existing facilities targeted, such as water treatment, supply and distribution systems, street lighting and electrical distribution systems, sewage treatment and handling systems and municipal buildings including municipal hospitals.

• Energy scenario - energy consumption details of all facilities included in the audit and their energy sources.

• Inventories - inventories of all relevant systems, including pumping, lighting, water treatment, supply and distribution systems.

• Baseline parameters and adjustments - methodology followed in establishing the baseline parameters and the criteria to be followed in adjusting it. Provide all the baseline parameters and the calculation procedure in an annex.

• Data collection - list the various types of data collected and their sources. Include the data in the annex.

• System mapping - describe the methodology followed for system mapping and include the maps in the annex.

• List of potential projects - a list of all identified measures with estimates of the savings and payback periods on investments, and a summary of the steering committee meeting decision selecting those projects chosen for further development.

• Review of current operation & maintenance practices - provide detailed description of current operation and maintenance (O&M) practices within the Municipal facility. This will include discussion with operators, engineers and other staff, observing the day to day O&M and reviewing the log sheet during the field study. The consultant has to identify areas for improvement and suggest the strategy and methodology for implementing it.

• Details of approved projects.

A number of success stories from across the world, but especially from emerging economies, are presented below for your benefit across a range of sectors. These demonstrate that a well-prepared energy audit study could lead to substantial savings for ULBs.

4.8 GOVERNMENT RESPONSE – GREEN BUILDINGS

Today, programmes for increasing market penetration of energy efficient products and processes exist in myriad forms - voluntary programmes, voluntary industrial agreements, building and appliance efficiency standards and labels, information programmes, best practices and benchmarking programmes, state market transformation programmes, financing and procurement. These programmes are being designed and implemented by government, industries and industry
Urban Infrastructure-I associations, public private partnerships (PPPs) and non governmental organisations (NGOs). Though so far the central government and industry associations have played a stronger role in this arena; but utility companies, regulatory commissions, and energy service companies are now beginning to assert their role. India has many central and local authorities and bodies that help compile building codes and standards that are applicable at the local and national levels. There are three significant codes/regulations that have been developed by national bodies:

- The Bureau of Indian Standards (BIS), National Building Code (NBC), which covers all aspects of building design and construction;
- The Bureau of Energy Efficiency (BEE), Energy Conservation Building Codes (ECBC), which target building energy efficiency; and
- The Ministry of Environment and Forests (MoEF), Environmental Impact Assessment (EIA) and clearance.

Among these codes/regulations, the ECBC is expected to have the most significant impact on a building's energy performance.

4.8.1 National Building Code

Building bye laws in India fall under the purview of state governments and vary in administrative regions within the states. BIS developed the NBC in the early 1980s as a guiding code for municipalities and development authorities to follow in formulating and adopting building bye laws. Today, NBC is the reference standard for most construction designs in the country. In its initial form the voluntary code covered most aspects of building design and construction, with only a small part dedicated to energy efficiency. However, the revised the NBC 2005, in its latest version provides guidance on aspects of energy conservation as well as aspects of sustainable development.

The NBC provides general guidance on potential energy efficiency aspects of factors like daylight integration, artificial lighting requirements and heating, ventilating, and air conditioning (HVAC) design standards. A new chapter on sustainability is being added to the NBC to provide a holistic approach to designing and constructing sustainable buildings. The chapter focuses on the integrated nature of design and adopts a cradle to grave approach for buildings.

4.8.2 Energy Conservation Building Codes

ECBC was formally launched in May 2005 as a provision of the Energy Conservation Act of 2001. As per the Act, ECBC will be mandatory for buildings with a connected load of 100 kW or a contract demand of 120 kVA or more. ECBC focuses only on the operation energy use impact of a building and specific maximum and minimum limitations on a number of key building features to reduce a building's energy use.

ECBC has both prescriptive and performance based compliance paths. The prescriptive path specifies the minimum requirements for the building envelope and energy systems (lighting, HVAC, service water, heating and electrical) that should be adopted. While the performance based compliance path requires the application of whole building simulation approach to prove efficiency over base building as defined by the code. ECBC takes into account location and occupancy...
of the buildings and provides minimum standards for reducing energy demand of the buildings through design and construction practices while enhancing the occupants’ comfort.

BEE is facilitating the adoption of the policy at the state level as well as providing technical support for the development of the codes and standards. A number of software, tools, tip sheets, case studies and a comprehensive user manual are now ready and available to the building professionals. The ECBC document is complementary to the NBC 2005. Several references to natural ventilation, day lighting, lighting, comfort, and other standards in the document are also detailed out in the NBC. The sustainability chapter of NBC refers to the ECBC document for specific energy efficiency standards for buildings and components. The EC Act and ECBC do not directly address the small commercial and residential building segment. The heaviest energy end use in these smaller buildings is in the form of appliances and equipment. This appliance energy use is being targeted through BEE’s energy efficiency standards.

4.8.3 Environmental Impact Assessment

The MoEF’s EIA is an important measure for ensuring optimal use of natural resources for sustainable development. EIA was made mandatory in India under the Environmental Protection Act (1986) for 29 categories of large scale developmental activities. The requirement for building energy performance in the EIA is a combination of related terms in NBC and ECBC. The EIA requirements are extremely pertinent and relevant, and if properly implemented, will result in a significant reduction in the environmental impact of buildings. In fact, buildings complying with the requirements of the MoEF’s EIA will fulfil most of the requirements of popular green building rating systems.

4.8.4 Green building rating systems

There are two major green building rating systems currently operating in India: LEED India and GRIHA. Industry associations and the private industry have played an important role in promoting the green building movement in India. The Indian Green Building Council (IGBC) is facilitating the Leadership in Energy and Environmental Design (LEED) rating of the United States Green Building Council (USGBC) in India. It has developed several India specific ratings, namely LEED-India, Green-Homes and Green-Factories. The IGBC also offers training, technical assistance, and other capacity building programmes to industry associations and industries. The Energy and Resources Institute (TERI) jointly with the Ministry of New and Renewable Energy (MNRE) has developed the Green Rating for Integrated Habitat Assessment (GRIHA) for the emerging energy consuming segment - the commercial, institutional and residential buildings. GRIHA has now been adopted as the national green building rating system and MNRE has developed incentives to promote it among architects and building owners. Additionally, MNRE has initiated several programmes for the integration of renewable energy in buildings.

In this section you have read about energy audit, government response – municipal demand side management and government response – green buildings. Now, answer the questions given in Check Your Progress 2.
Check Your Progress 2

Note: a) Write your answer in the space given below
   b) Compare your answer with those given at the end of the unit.

1) What are the key requirements for an Urban Local Body to develop capacity for sustainable urban energy planning?

2) Describe key elements of undertaking a preliminary energy audit.

4.9 LET US SUM UP

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 is critical, and will be the focus of this Unit. The fundamental goal of energy management is to produce goods and provide services with the least cost and least environmental effect. The fundamental goal of energy management is to produce goods and provide services with the least cost and least environmental effect.

Energy management includes planning and operation of energy-related production and consumption units. Objectives are resource conservation, climate protection and cost savings, while the users have permanent access to the energy they need. It is connected closely to environmental management, production management, logistics and other established business functions.

4.10 REFERENCES AND SELECTED READINGS

• Bureau of Energy Efficiency, India – www.bee-india.nic.in
• India Infrastructure Report, 2006. 3IE Network.
• Prime Minister Action Plan on Climate Change, Government of India.
• UN-HABITAT, 2009. Sustainable Cities Programme: Sustainable Urban Mobility Component - www.scp-mobility.org
• en.wikipedia.org/wiki/Energy_management
• www.waterway.org/resources/casestudies/vishakhapatnam_india.pdf
• www.watergy.org/resources/casestudies/veracruz_mexico.pdf
4.11 CHECK YOUR PROGRESS-POSSIBLE ANSWERS

Check Your Progress 1

1) What are the key principles of Sustainable Urban Energy Planning?

Ans: The key principles of Sustainable Urban Energy Planning are

1) Sustainable Use of Energy Resources
2) Ecological Community Form and Function
3) Environmentally Sound and Energy Efficient Land Use Optimization
4) Energy and Environmental Technology Integration
5) Community Resources Management
6) Social Equity and Economic Vitality

2) What do you understand by ‘Zero Net Energy’?

Ans: Zero net energy (ZNE) refers to a building or development with a net energy consumption of zero over a typical year. To cope with fluctuations in demand, zero energy buildings or developments are typically envisioned as connected to the grid, exporting electricity to the grid when there is a surplus, and drawing electricity when not enough electricity is being produced. The amount of energy provided by on-site renewable energy sources is equal to the amount of energy used by the building or development. A ZNE building or development may also consider embodied energy – the quantity of energy required to manufacture and supply to the point of use the materials utilized for its building.

Check Your Progress 2

1) What are the key requirements for an Urban Local Body to develop capacity for sustainable urban energy planning?

Ans: Local governments have engaged in sustainable energy planning in three principal ways:

- Reducing energy consumption within their own facilities and operations;
- Promoting efficient energy use and alternative resources in the private sector through judicious use of incentives, regulations and demonstration projects; and
- Shaping local land use and development patterns to reduce per capita energy use and improve environmental quality.

2) Describe key elements of undertaking a preliminary energy audit

Ans: Preliminary energy audit is a relatively quick exercise to achieve the following and uses existing, or easily obtainable data.
• Establish energy consumption in all ULB assets (buildings, water supply, sanitation, solid waste management, streetlighting, etc.);
• Estimate the scope for saving;
• Identify the most likely (and the easiest areas) for attention;
• Identify immediate (especially no-/low-cost) improvements/savings;
• Set a reference point that the ULB may want to achieve; and
• Identify areas for more detailed study/measurement.