UNIT 7 ENERGY PLANNING

Structure

7.1 INTRODUCTION

In the previous unit, you have studied about various features of the energy policy. You have learnt that the energy policy of a country should aim at ensuring energy security, providing the required energy services at the least cost, using indigenous and renewable sources of energy, and implementing measures for mitigating environmental problems at local, national, regional and global level. Promoting the efficient use of energy is a principal feature of a meaningful energy policy. **Energy planning,** which forms the subject of this unit, is the key to effective implementation of the energy policy. A well-thought-out energy plan can improve the economic, environmental and social impact of nearly all decisions about how energy is used, generated, distributed or imported by a nation or a community, both now and in the future.

In Block 1, you have learnt about the linkages between energy and various sectors of the economy: agricultural, industrial, commercial and domestic. We need to make the current energy use and production environmentally benign. At the same time, these should be able to meet everybody's energy needs in a sustainable manner. You know that we have better technologies than ever before to use energy efficiently, and to use the world's renewable energy resources without harming the environment. Sustainable energy planning can help us optimise the use of the existing capacities as well as the development and use of energy efficient systems and appliances, and importantly, an efficient energy management system.

What are the objectives of energy planning? What does the process of energy planning involve at the national and local level? What are the strategies that can be used by nations, local municipalities and energy supply utilities for bringing about these changes? What roles can we play in this process at the individual and community levels? These are some of the questions we address in this unit with a focus on urban energy planning. In the next unit, we look at the Indian energy scenario and rural energy planning in the Indian context.

Objectives

After studying this unit, you should be able to:

- explain the concept of energy planning and outline its objectives;
- discuss the process of energy planning at macro-level and at local level in urban areas; and
- analyse the role of national and local governments, communities and individuals in energy planning.

7.2 WHAT IS ENERGY PLANNING?

Energy planning is the process of envisioning a desired future state of sustainable energy supply and consumption based on existing concerns and realities, and designing the appropriate measures to implement that energy future. It offers a number of opportunities and tools for nations and communities to deal with energy issues related to development. Energy planning is not a one-time exercise, but a continuous, iterative process in which the results are continuously reviewed and new information leads to new analyses.

Energy planning is extremely relevant for developing countries as it can be used to overcome the limitations that inhibit sustainable energy strategies. These limitations may arise from a number of factors such as:

- The limited trained human and financial, and in some cases, natural resources available to developing countries for addressing energy problems;
- The complex relationship between the need to provide better energy services and the need to limit total energy consumption; and
- The lack of technological know-how for mitigating environmental problems associated with energy production and use.

Energy planning helps in creating a picture of the current energy situation and estimated future changes based on expected or likely plans and patterns of population growth, resource availability, industrialisation, agricultural energy requirement, etc. It has to be designed to make sure that it furthers the interest of society as a whole and is used to meet social goals such as improving the quality of life, environmental goals such as climate protection and sustainability goals.

Whereas traditional energy planning focused on sectoral energy demand and supply, increasing emphasis is now being laid on environmental issues, sound social development and healthy economic growth. A steady growth in demand for energy is no longer deemed synonymous with development, as many energy intensive developmental efforts may prove to be unsustainable in the long run.

New approaches to energy planning have evolved as a response to the increasing recognition of the significant economic, environmental and social costs associated with current patterns of development in both urban and rural areas (see Fig.7.1). These include issues such as unsustainable resource use, urban sprawl, traffic congestion, water and air pollution, loss of affordable housing, energy conservation, loss of open space and areas of high environmental sensitivity (e.g., forests, wildlife preserves, etc.), lack of development in rural areas, rural energy poverty.

Fig.7.1: The need for energy planning stems from the environmental, social and economic costs of unsustainable energy use in the current development paradigm

The current approaches to energy planning aim at providing energy services (as distinct from energy per se) to the society at lowest cost and with the least negative social and environmental impacts. For example, instead of demanding more electricity or more petrol, we should look at the issue of providing services like lighting, heating, cooling, running machines and appliances, mobility, comfort, etc.

We should ask: How can these services be provided in the cheapest and most efficient way, meeting all social, environmental and financial costs?

Energy planning enables the policy makers / decision makers to examine in an integrated manner, **the critical relationships between supply and demand, land use, bio resource issues, environmental sustainability, economic development** and **resource sharing.** Integrated energy planning takes into account techno-economic aspects such as spatial variation and seasonal variation in resource availability, energy demand, energy technologies, relating energy consumption to macro-economic factors like GDP and population. It also includes social aspects such as decision structures, levels of decision making, and implementation strategies that ensure the participation of all stakeholders.

In the current energy planning paradigm, a systematic analysis of all possible strategies to meet the energy needs is undertaken, taking into account all future scenarios. It also helps in developing alternative scenarios with assumptions such as:

- Transformation (e.g., through introduction of energy efficient devices such as fuel efficient stoves, improved furnaces, boilers, pumps, motors, dryers, compact florescent lamps, light emitting diodes, etc.);
- Use of advanced control systems and features;
- Increase in energy intensity (such as rapid industrialisation with an energy demand increase of, say, 20%);
- Increase in energy demand in domestic, industrial, agricultural and commercial sectors;
- Expansion of renewable energy technologies (solar, hydro, bio energy etc.) and agro forestry (conversion of wastelands with locally accepted species).

Thus, it helps provide a range of optimal policy alternatives in a common socio-economic framework. Transparency, review by experts, SWOT (Strengths, Weaknesses, Opportunities and Threats) analysis and participation of stakeholders at all stages are essential ingredients of energy planning.

Energy is linked with almost all economic sectors such as agriculture, industry, commerce, trade, transport, telecommunications, etc. Therefore, energy planning also requires the development of capabilities of related institutions. It requires the cooperation between various agencies from these sectors for the planning to be effective. At present these capabilities are still limited in Asian countries and cooperation is not yet adequate. At high level, decision-makers often lack understanding of the energy scenario. Energy planning is thus one of the most challenging tasks facing governments, and societies today.

Energy planning can be carried out at the **macro-level** (or national) as well as at the **regional or local levels** (e.g., state / district / town/ taluk / block/ village levels). Macro-level planning covers longer time spans and considers more sectors and processes. However, centralised macro-level energy planning exercises cannot pay attention to the variations in socio-economic and ecological factors of a region which influence the success of any intervention.

Decentralised energy planning based on the assessment of local or regional needs and available resources can lead to more efficient utilisation of resources. This implies that the assessment of the demand and supply and the intervention in the energy system which may appear desirable due to such exercises must be at a **similar geographic scale.** You will appreciate this point better when we discuss urban energy planning. Area based decentralised energy plans should be incorporated into the centralised energy plan. This seems to be realistic in view of large scale variations in the energy consumption patterns.

Energy planning may also be carried out as a project, which focuses on one or more specific aspects, e.g., reducing the energy costs of a business, increasing the efficiency of energy use in a municipality or introducing renewable energy options for meeting the heating / cooling needs of a building. Implementation of specific projects requires preparing concrete proposals, and having an effective and efficient system of performance monitoring, evaluation and control.

With this brief introduction to the concept of energy planning, we now outline the major aims and benefits of energy planning.

7.2.1 Aims and Benefits of Energy Planning

The broad **aims** of macro-level energy planning are:

- To provide the basis for the policy framework and to assist state agencies and other energy-related organisations in **setting the energy goals** and making energy decisions that will contribute to a growing economy in a sustainable and environmentally sound manner.
- To help in **finding and allocating the resources** (funds, technologies, skilled workforce, etc.) for **meeting the specific energy requirements**/demand of all sectors in an optimal manner. This includes minimisation of the total costs of energy, minimisation of non local resources, and maximisation of overall system efficiency.
- To increase the use of design philosophies and features that improve energy performance, and enhance the quality of life.
- To develop compact and "complete" resource use patterns so as to increase the availability of alternatives.
- To promote the development and use of new, high efficiency, and "cleaner" supply options.
- To promote the use of energy-efficient technologies or service options in infrastructure and to increase the production of energy from local or regional distributed facilities.

More **specific goals** of local level (area based) or project based energy planning may include:

- encouraging reductions in energy consumption and costs through energy audits and investments in efficiency opportunities;
- encouraging the planning , design and construction of energy efficient neighbourhoods and buildings in urban areas;
- assessing the scope and extent of energy use efficiency so that both energy and money are saved;
- exploring local renewable energy development potential;
- improving community liveability by reducing local sources of pollution, reducing the need for transportation through proper urban design;
- increasing the use of cleaner energy alternatives;
- providing information and help to users to implement local energy plans; and so on.

Benefits of Energy Planning

Energy planning has many benefits, some of which are outlined below:

GIS supported energy plan serves as a demographic database, natural resource database (e.g., land use, land cover, forest types, wastelands, agriculture-crop types, production, yield, irrigation details, horticulture-crop types, residues, plantation area and plantation types, social forestry programmes) and energy database.

It is possible to update data, edit it, address queries, retrieve data, generate reports, and generate graphs and link to spatial maps at the national / state/ district / town / taluk / village levels.

Energy plans can be used as forecasting tools to make projections of energy supply and demand at intervals of 5 years and as policy analysis tools that simulate and assess the technical economic, environmental effects of alternative energy programmes. A number of simulation models and tools are now available, which can be used to decipher the energy planning practices in a much better way.

Energy plans provide comprehensive information at one place about renewable energy potential, supply status of commercial sources of energy (electricity, oil, kerosene, etc.), estimation of energy demand of various sectors, techno economic and environmental assessment of alternatives. They can be used to promote efficient use of resources including land, energy and capital. Thus, they can help protect an area's natural features and environmentally sensitive areas.

Energy planning helps reduce energy expenditures of governments and taxpayers, saves non-energy capital and operating expenditures. A transition to efficiency and renewable energy options can result in huge amounts of money freed for other investments, millions of new jobs, a healthier environment, and greater comfort and productivity. When households, businesses, and governments cut energy expenses, they have more disposable money to spend on other priorities. For example, local schools can spend more money on education instead of on lighting classrooms: They can use day lighting techniques in the school buildings to save on electricity. Businesses can increase productivity instead of spending money on inefficient energy use. And families can increase their quality of life instead of worrying about high energy bills. In addition to these direct benefits, the money saved from reduced energy bills circulates in the economy, creating additional benefits. Depending on the type of products made and sold, a "multiplier effect" creates a ripple of benefits throughout the economy.

Energy planning helps increase land values in urban areas through better land use planning. For example, the low-value use of land for parking lots, roads, telephone exchanges, service stations, etc. can be converted to high value use for buildings and commercial services. It also helps preserve the value of non-financial land. For example, agricultural land, wetlands, forest and wildlife areas, and community watersheds have important non-financial functions, and are being threatened in many regions by the encroaching urban development or by transmission corridors for electricity and natural gas. An energy plan involving more compact urban form, lower energy needs, and local energy supply systems can help alleviate these pressures.

Good energy planning can reduce the costs of infrastructure. For example, infrastructure in expanding urban areas is in constant need of periodic costly upgrades and expansions. Moderate density, mixed use and contiguous development patterns decrease the cost of linear infrastructure (roads, sewer lines, water lines, telephone cables, electric supply lines and gas supply lines) simply because fewer kilometres of line are needed to serve the same customer base. This can reduce the development costs as well as long term maintenance costs. The cost of "response-time" services (fire, ambulance, police, etc.) can also drop.

Energy planning helps in cleaning up the environment through preservation of green spaces. It reduces climate change due to greenhouse gas emissions by reducing exclusive dependence on fossil fuel combustion. Further reductions can be made through the capture and use of landfill methane for supplying energy. It helps reduce local pollution such as air emissions from vehicles, buildings and factories, urban runoff to lakes and rivers (for example, motor oil and transmission fluids), increased solid waste (for example, non-recyclable automobile scrap), land and groundwater contamination (for example, transformer oil and PCB spills, leaking underground fuel storage tanks). Community energy planning can reduce local pollution by optimising transportation (e.g., providing better public transport and reducing single occupant vehicles), reducing energy consumption, and increasing the use of cleaner energy alternatives. Neighbourhood car pooling schemes can be pursued more vigorously.

Energy planning achieves many socio-economic objectives, such as increased local employment and the creation of jobs through investments in energy, lower annual energy bills, better indoor working conditions through the use of advanced building, heating, cooling and lighting technologies. Many of these social benefits also have financial benefits. For example, cleaner air leads to fewer health problems, which saves on medical expenses, better working environment leads to greater productivity and cost savings. Savings due to lower energy bills result in a re-spending effect as people spend them in the local economy.

Money spent on commercial fuels and electricity does not remain with the local community. Keeping this money in the community – either by reducing bill payments, investing in efficiency instead of supply, or investing in local supply options – stimulates the local economy. Whereas relatively few permanent jobs arise from large-scale centralised facilities, local energy facilities provide more jobs to more people. For example, a programme to produce ethanol from sugar cane helped create 700,000 jobs in rural areas in Brazil.

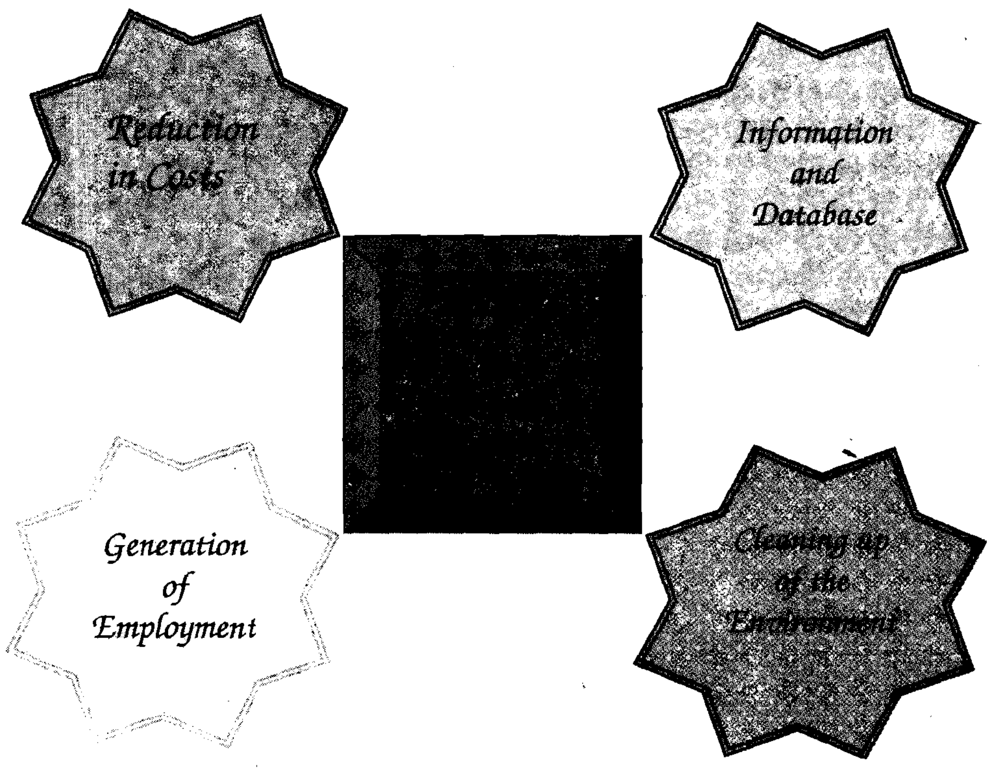

Fig. 7.2: Some benefits of energy planning

Sustainable energy practices can also directly generate new jobs and businesses. For example, they require an investment in new technologies, insulation, efficient light bulbs, solar water heaters, super-efficient windows, etc., as well as new skills and services. Local businesses can offer these products and services and benefit from the increased demand for them. If such products and services are unavailable locally, community entrepreneurs can create new jobs and businesses to meet the demand. Jobs related to energy supply tend to require skills in occupations where there is little underemployment. Local communities can be trained in the kinds of skills needed for such energy enterprises. Component manufacturing at the local level may well take the shape of a local cottage industry, if managed well.

The discussion so far applies more to the industrialised countries and the higher income sectors in developing countries. There is a need for strict energy conservation in high-energy-consumption areas for these categories because in both situations, an increase in energy consumption does not improve the quality of life; rather it can even deteriorate it. It surely does not make sense to project increases in commercial energy consumption for countries or sections of populations that consume the largest amounts of energy (estimated to reach 10,000 to 15,000 kgoe per capita by the year 2025). Today, there are 81 countries, with a total population of 4,750 million people (87 percent of the world's population) that have not yet reached 3,000 kgoe per capita, and 62 countries, with a combined population of 3,800 million people (70 percent of the world's population) that do not use even 1,000 kgoe per capita.

The lower income sectors in developing countries face different problems stemming from an acute shortage of energy supply, lack of equitable distribution of available energy and ways of increasing their (useful) energy availability have to be found. We now discuss this dimension of energy planning. But before studying this aspect, you may like to reflect on the ideas presented so far.

SAQ 1

Outline the goals of a suitable sustainable energy plan for your area (home, workplace, village or community). What benefits would you expect from such a plan?

7.2.2 Energy Planning in Developing Countries

Developing countries are highly diverse in their social and economic systems and conditions. Energy planning in developing countries has to take into account the distinctions between urban and rural areas and between literacy and income levels. Marginal sectors of society face acute energy shortages and have totally different energy needs.

A large fraction of the total energy consumption in developing countries does not come from commercial sources. Many energy requirements are not satisfied because of supply restrictions. A large number of potential consumers in developing countries cannot access energy sources due to physical, systemic or economic constraints. An enormous gap exists between current consumption levels of the rich and the minimum reasonable requirements of the poor sections of the developing country populations. Let us elaborate on these points.

The modes of production differ considerably in rural and urban areas. For example, in rural areas, they range from subsistence farming, to artisanal production to intermediate commercial systems that supply local requirements. These coexist in urban areas with sophisticated modern export-oriented systems. So we have roadside potters, blacksmiths, hawkers, vendors and mechanics with low energy requirements as well as mechanised workshops, factories, shopping malls, etc. in urban areas.

In the manufacturing sector, the range extends from crafts, to small- and medium-sized industries, to large high-technology industries. A variety of production modes are used for the same activity, obtaining the same product, or the same service. These can have different levels of energy consumption that can be met from a variety of sources. For example, weavers producing cloth on handlooms or power looms would have different energy requirements from those of textile factories.

Thus, we need to make a detailed study of the technology associated with each production mode, taking into account specific energy inputs, as well as the energy associated with other inputs or production factors.

Transportation ranges from traditional animal driven carts, to organised public transport and private vehicles using modern technology. Similarly, the services sectors include informal, individual activities in the unorganised sectors in rural and urban areas (e.g., vendors of goods, wandering repairmen and roadside mechanics) to modern commercial centres and services (e.g., hospitals and telecommunications) making use of the latest technology.

The agricultural sector relies heavily on the use of human and animal energy, which has to be taken into account while assessing the possibility of substitution or of improving the energy use efficiency. In the industrial sector, the technologies most suitable for a given need and the available natural and energy resources of a country have to be identified. The energy requirements of the agro-industrial sector must be carefully assessed just as the energy requirements of other industries (e.g., cement or steel are assessed). You could think of many more similar situations around you.

Fig.7.3: The diverse range of energy use in developing countries

For the developing countries, the best way of preventing the negative impacts of energy consumption on the natural and human environment is not consuming or producing more energy but increasing their level of energy services. To achieve sustainable human development, they must increase their useful energy consumption. Thus, the solution must not necessarily be to increase supply, but to focus on a Rational Use of Energy (RUE), energy conservation, and adequate Demand Side Management (DSM). This is particularly true in urban areas and in activities related to transportation, industrial production, and services.

Rational use of energy and energy conservation are not contradictory with the need to increase energy services. Moreover, it is both possible and necessary to apply these principles not only in developing countries, but in industrialised countries as well.

The point being made here is that energy planning in developing countries must correspond to their own real time situations. We cannot blindly apply the analytic frameworks, technologies, or solutions relevant for industrialised countries to developing countries. The conditions, resources, and social and cultural patterns of the developed and developing countries are very different.

To sum up, energy planning is very useful from all perspectives: social, economic and environmental. However, energy planning in developing countries must correspond to their own needs and social conditions.

If developing countries are to adequately pursue Energy Planning based on their own resources, interests, and problems, they must form their own understanding of these issues, acquire technical expertise in all aspects and train appropriate workforce that has access to the centres of government, where decision-making power rests. Above all, planning in these countries must be a participatory process in which all those affected take part, including users, producers, workers, professionals, enterprises, and local, regional, and national interest groups.

7.3 THE PROCESS OF ENERGY PLANNING

Energy planning, as you have learnt, is a continuous, iterative process which should first **assess energy requirements** consistent with sustainable human development objectives and the lifestyle preferences of the whole population. These objectives and preferences should then be pursued through a **supply system** that is autonomous, safe, and fair and that limits (to the extent possible) the socio-economic costs of doing so. The supply and consumption systems must try to **maximise the positive effects on the environment and the social and economic systems, and to minimise the negatives ones.**

A GIS is a computer system capable of capturing, storing, analysing, and displaying geographically referenced information; that is, data identified according to geographical location. Practitioners also define a GIS as including the procedures, operating personnel, and spatial data that go into the system.

Different kinds of data in map form can be entered into a GIS. A GIS can also convert existing digital information, which may not yet be in map form, into forms it can recognise and use. For example, digital satellite images can be analysed to produce a map of digital information about land use and land cover. Likewise, census or hydrologic tabular data can be converted to a map like form and serve as layers of thematic information in a GIS.

A full-scale energy planning effort thus involves compiling an energy data base, examining the critical relationships between supply and demand, taking into account issues of sustainable resource use, environmental sustainability and economic development, stimulating local energy awareness, examining existing energy goals and objectives for their effects on energy production and use, and suggesting institutional mechanisms for all stages of the plan.

The following activities may be identified as a part of the energy planning process:

- data base development,
- supply and demand analysis,
- assessment of economic, social and environmental impacts,
- creation of research and development facilities,
- creation of institutional mechanisms for the participation of all stakeholders in the planning and implementation process,
- schemes for implementation including awareness, capacity building and educational programmes,
- setting up monitoring, follow up and evaluation mechanisms.

We now discuss the energy planning process, in brief.

Database development and management is one of the most important steps in the process and requires careful thought, money and time. Effective energy database management provides the planner with information to properly allocate budgets and resources, make forecasts (for multiple scenarios), and manage costs and risks. Risk benefit analysis can be done using this data.

Energy database contains physical data on **energy supply**, i.e., energy resources, their productivity and accessibility, patterns of resource distribution and resource use options. The existing supply options (power plants, import options etc.) must also be enumerated. This includes data on renewable and non-renewable energy resources (e.g., solar insolation, water resources, land use, forest cover, wastelands, agriculture-crop types, production, yield, horticulture-crop types, plant residues, coal, oil, natural gas, etc.), their potential and availability along with seasonal and spatial variations. For example, a water source such as a water fall may be present in the vicinity of an area but it may not be possible to extract useful power from it due to low volume of water, low flow speeds or low height of the fall. Or, it may not be possible to extract a resource (oil or coal) at economical costs. So it may be viable to go in for the import of such commodities.

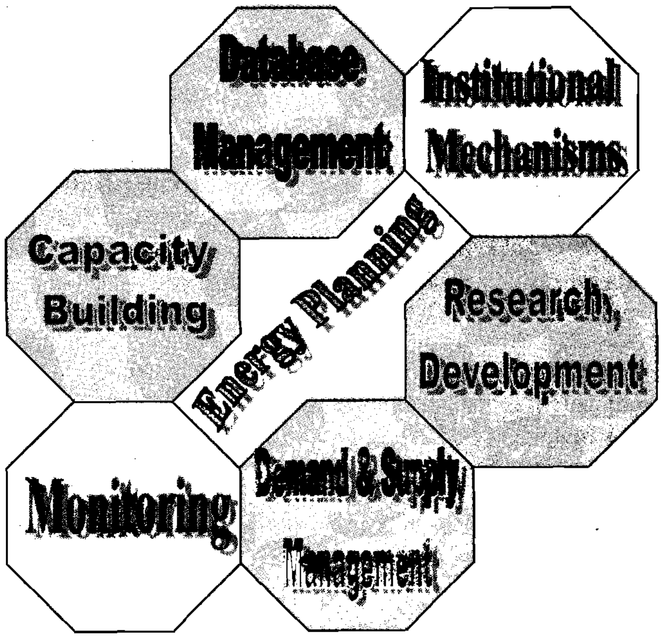

Fig.7.4: Some aspects of the energy planning process

The database has information about sector wise energy demand / energy consumption in all sectors: domestic, industrial, commercial, public services, agriculture and forestry, and transport. A breakdown of energy demand by fuel source within these sectors is also included. It informs about, e.g., patterns of average household energy use, energy needs in agriculture (activity wise), transport (e.g., total vehicle kilometres travelled), and commercial and industrial energy use.

The database should highlight exceptions where attention must be focused. The database also has information about the present and expected future energy/electricity demand including the total energy needed, peak power, load curve(s) and load forecasts for future energy needs, systemic data such as network losses and limitations of the grid, expected future development including expected increase of end-use efficiency. It should also provide estimates of capital, operation and maintenance costs of energy infrastructure.

Energy database also includes environmental database, which provides comprehensive information about the environmental consequences of energy use, distribution and production, e.g., siting, waste generation, pollution as well as the environmental impacts of energy alternatives. Socio-economic parameters such as income levels that determine paying capacity and affordability, acceptability, existing skills, training needs are particularly relevant for rural energy planning.

Many useful tools are available for compiling the database and GIS (Geographical Information Systems) is one of them. It can be used to map resources and evaluate potential resource use options against specific indicators of resource efficiency and quality of life.

Similarly, **global positioning systems** can be put to use for keeping a tab on those collecting energy data. You may know that the **Global Positioning System** (GPS) is a worldwide radio-navigation system formed from 24 satellites and their ground stations and can be used to track aircrafts, cars, cell phones, boats, and even individuals anywhere in the world.

Managing energy demand and supply are the key elements of the energy planning process. Improved planning and/or management of these elements involve identifying:

- the optimal pattern of end-use demands, ensuring that it matches the requirements of a growing economy, including sectoral needs, incorporates demand conservation measures and achieves improved efficiency in utilising devices; and
- the optimal energy supply system, including technically efficient extraction, conversion and distribution of energy, and application of the most appropriate and cost-effective production technologies.

In view of the **adverse environmental impacts of energy production and use** (recall Unit 4), **environmental management has now become an integral part of the energy planning process.** The failure to address environmental concerns is likely to lead to constraints on future expansion of energy utilities.

A recent innovation of relevance to energy planning is the concept of **industrial ecology**. Industrial ecology draws an analogy between natural ecosystems (where nothing is wasted), and the industrial system, including the energy sectors. In this model, energy and material residuals are no longer wastes discharged to the environment. Instead, they become valuable resources for the economy.

The traditional approach to energy planning involved **preventing energy shortages by increasing the supply** (e.g., supply of electricity was sought to be increased by building a new dam or fossil fuel power plant). This approach is called **supply side management**. It generally involves identifying

- how much energy is required to eliminate an impending shortage,
- determining the kind of energy that could best meet that demand, and
- selecting an appropriate site.

You have studied about the variety of energy supply options available today. Many energy supply technologies can be applied at several scales of planning, from regional planning to localised sites. The era of mega hydropower projects is, by and large, over in developed countries and is meeting stiff resistance in developing countries due to appalling social misery and environmental costs that such projects bring in their wake.

The world is moving towards **distributed, decentralised utilities managed by local communities**. Both new and established energy technologies, frequently located inside buildings themselves, generate electricity and useful heat. This type of electricity generation mode is known as the **captive system** of localised energy fixation.

For example, mature technologies are now available for simultaneously producing heat and power in stand-alone units suitable for on-site installation. Systems can be owned and operated by developers, building owners, or energy service companies as a revenue generating venture or by owner/tenant cooperatives as a community based cost-saving initiative. Various options like the BO (build, own), BOO (build, own, operate), and BOOT (build, own, operate, transfer) are available.

Many commercial activities are net generators of heat, while residences are net heat users. Mixed uses within a building, especially with commercial uses on the ground floor and residential units above, are being used for saving energy. This helps in **energy optimisation**.

A variety of renewable energy supply forms are now being used for remote communities or communities not connected to electricity or natural gas grids. Technological innovations support these trends. For example, the least expensive size of electric generators has been dropping rapidly.

Energy Supply in Developing Countries

The following characteristics of developing countries may be considered in assessing energy supply:

- insufficiently developed local energy sources; large gap between the resource potential and that actually realised;
- diversity of available systems and technologies (including, for example, such old technologies as firewood stoves and such new technologies as micro computers);
- highly dispersed demand, which, in turn, complicates supply systems;
- dependence on foreign appliances, research and development; and
- lack of adequately trained and experienced human resources essentially for even routine operation and maintenance.

Energy resources (such as biomass, hydroelectricity, solar energy, geothermal energy, etc.) in many developing countries are not developed because they are not large enough. Besides, they may not have the economies of scale of interest to the international market due to their location or lack of easy access. Yet if developed, they could contribute to increasing energy self-sufficiency at the local level and improving the quality of life. An added benefit is that they help in controlling greenhouse gases, both locally and globally. For example, in Latin America and the Caribbean, the massive development of hydroelectricity between the 1960s and 1980s made that region the lowest in the world in terms of carbon dioxide emissions per unit of energy consumed. Between 1975 and 1985, Latin America and the Caribbean attained the greatest reduction in carbon dioxide emissions.

In the 1970s when the world was hit by the first major **energy crisis**, it became clear that some of the most convenient **fossil energy reserves**, such as crude oil, would not last forever. The search for equally cost-effective alternatives was not making much headway. It was then that the focus shifted from supply side management to managing energy demand which sought a **reduction in the demand for energy instead of a simple increase in the supply**. This approach was termed **demand side management**. Let us learn about it in some detail.

Demand-Side Management and Energy Efficiency

Demand Side Management or "DSM" is the **process of managing the consumption of energy**, generally to optimise available and planned generation resources. It involves **using existing energy supplies more efficiently and improving efficiency of energy use. Demand-side management (DSM) comprises all planning, implementing, and monitoring activities and measures designed to improve efficient use of energy and encourage consumers to modify their level and pattern of energy usage**. It includes:

- **reduction in the total quantity of energy consumed by users through better load management;**
- **energy conservation** measures for **using lesser energy to produce similar or greater output** and **minimising losses in existing processes of energy production and use**;
- **resource and/or technology substitution**, i.e., altering the mix of a given energy system by replacing less efficient fuels with more efficient fuels or by introducing new technologies that are more efficient;
- structural changes by **shifting away from high energy-intensive industries to high capital- or labour-intensive industries** or **by changing lifestyles that encourage excessive energy consumption**; and

- **reduction in the demand for energy (e.g., electricity or gas) at peak times when energy supply system is strained and to shift demand from peak to off-peak times.**

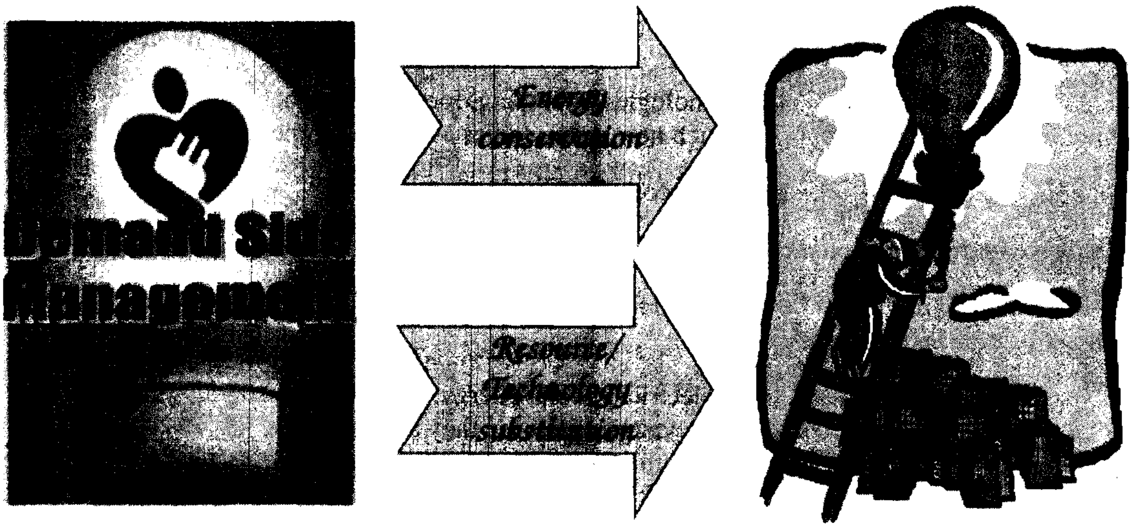

Fig.7.5: Important features of Demand Side Management

Specific measures include incentives for not using power during peak hours, full cost pricing, encouraging the use of more efficient equipment and technologies that save both energy and money. For example, consumers could change the amount or timing of electricity consumption in order to utilise scarce electric supply resources most efficiently, far more energy can be saved by optimising the size and design of a pump than by improving only the efficiency of the motor that drives it.

Traditionally, DSM was driven by electricity businesses as a *load and investment management tool*, often within a *least-cost planning framework*. While this aspect continues even today in some countries, DSM is increasingly finding new applications in liberalised energy markets as an important tool to:

- help balance the supply and demand of energy,
- reduce price volatility,
- increase system reliability and security,
- rationalise investment in energy supply infrastructure,
- reduce greenhouse gas emissions, and
- incorporate the RETs in the energy planning regime.

Demand side management is primarily achieved through

- technology changes and/or
- consumer behaviour changes.

An energy conservation measure such as replacing incandescent lights with more efficient compact fluorescent bulbs is an example of a technology change. Similarly, using a thermostat operated electric geyser is a better technology option than the immersion rod for heating water.

Turning lights off when they are not needed is an example of a behavioural change.

Several **load reduction technologies**, e.g., energy-efficient lighting, appliances, and building equipment, etc. are used to reduce total energy use. Commercial building energy consumption can be reduced by an average of 55 percent primarily through controlling lighting and air conditioning loads. About 25 percent of power consumed by motors could be saved through use of power factor controllers. These are essentially energy conservation technologies. Fig. 7.6 presents useful information on power consumption by a variety of household appliances when these are not being used but are kept on in the standby mode.

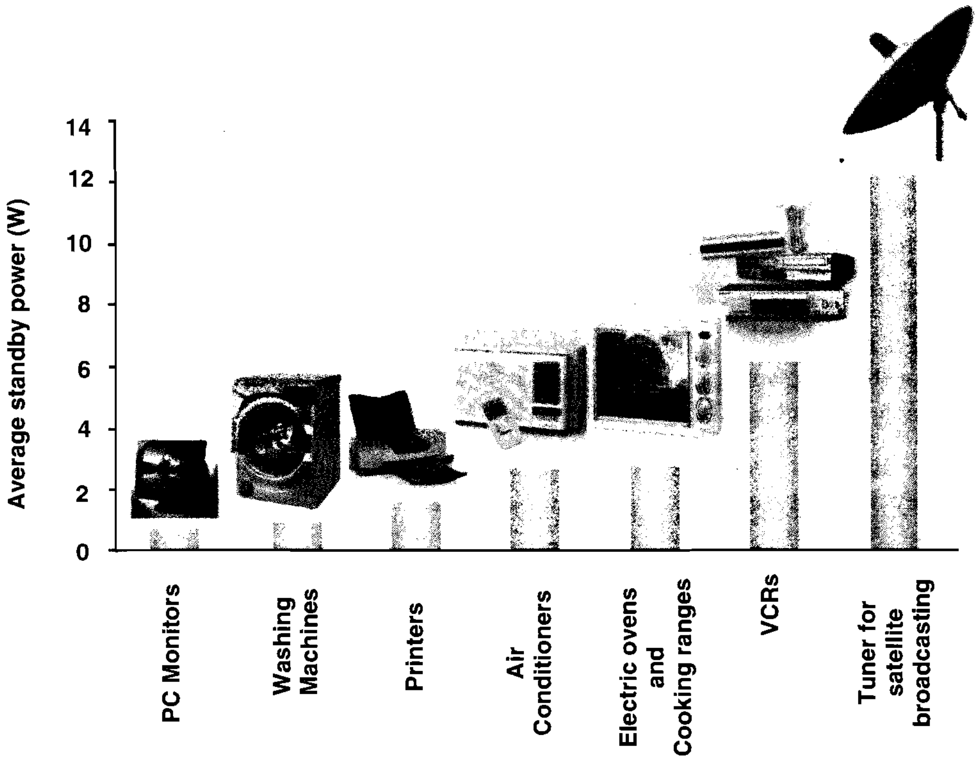

Fig.7.6: Power consumed by various devices and appliances in the standby mode

Many opportunities to implement demand side management can be uncovered simply by attitudinal changes. For example, by recognising that **we don't just want energy, we want the services that energy provides**. For instance, we should be happy to use an energy efficient fridge versus a standard fridge provided that both provide the same services (i.e., they both keep our food cold).

There are many other ways of influencing the consumer's behaviour to reduce energy demand (e.g., the amount or timing). These include reducing the peak demand by spreading out the consumer load more evenly over the entire daily or weekly period. Load levelling technologies are used to smooth out the peaks and dips in energy demand y reducing consumption at peak times, shifting the load from peak to off-peak periods, or increasing it during off-peak times.

One strategy commonly used in developed countries to change the timing is to charge more per kWh during high demand periods, such as during business hours in daytime or dinnertime. Such a pricing policy encourages consumers to defer non-critical electrical loads such as operating a clothes drier to off-peak times. **Energy storage devices** located at the consumer's end are also used to shift the timing of energy consumption.

Energy management control systems (EMCSs) can be used to switch electrical equipment on or off for load levelling purposes. Some EMCSs enable direct off-site control (by the electric supply company) of user equipment. Typically applied to heating, cooling, ventilation, and lighting loads, EMCSs can also be used to invoke on-site generators, thereby reducing peak demand for grid electricity.

Many DSM programmes include measures such as:

- Direct load control switches that allow the electric company to control appliances such as air conditioners during periods of maximum demand;
- Energy efficiency retrofits (weatherisation) of homes, particularly for low-income customers;
- Energy audits for commercial businesses and industrial units;
- Small rebates to install certain types of efficient new equipment such as geothermal heat pumps;
- Assistance in financing efficiency improvements;
- Information about energy for school children and the general public;
- Information about efficient construction methods for new homes, etc.

The idea is to encourage people to use more efficient energy technologies to get more power for the same amount of energy inputs and reduced costs as well as to change the ways in which they use energy.

Thus, the **essential components of the demand-side management and energy efficiency domain** are:

- Efficient appliances;
- **Efficient components for buildings**;
- Methods to manage an assembly of appliances and systems in order to improve the use of energy system capacities;
- Economic criteria for **the energy and environmental planning** process.

Community energy planning also falls under the general category of demand side management. It involves municipal governments, planners, developers, businesses and residents making sure that homes and communities are built in a way that conserves energy, e.g., encouraging clustered housing, modifying building codes to increase insulation. For example, this may include the mandatory use of double glazed windows particularly in buildings having energy consumption above 500 kW. This is also being enforced in India according to the very recently approved National building energy code for Indian buildings. You will learn more about this aspect in the next section.

Benefits of DSM

Properly planned and managed Demand Side Management (DSM) initiatives such as **energy efficiency and load management programmes** can:

- Reduce energy usage;
- Enhance customer service;
- Reduce operational costs; and
- Create new revenue streams.

Other benefits of DSM include reduced pollution, reduced bills for customers, reduced price volatility, improved reliability of the electric grid, and improved resilience against accidents.

In the developed countries, there are examples of DSM services that have reduced load by over 1,700 MW and saved customers more than USD 7 billion in energy costs; protected the environment by eliminating over 126 million tons of carbon dioxide emissions – equivalent to taking 1.7 million cars off the road each year.

One such service in the USA analysed over five million households through on-line, mail-in and on-site energy audits throughout North America, provided energy analysis and implementation services for more than six billion square feet of commercial and industrial floor space, and designed a wide variety of incentives and energy saving programmes for residential, commercial and industrial customers.

Renewable Energy Use for DSM

Problems such as shortage of power during peak hours and poor quality of power can also be handled by incorporating renewable energy systems in the DSM programmes. For example, a small PV capacity can be added to boost the voltage at the tail end of a distribution network. This helps to arrest the poor quality of grid supply. In case of the multi-storied office complexes, the same PV capacity can be added to augment the grid supply during the peak load hours instead of shutting down part of the load.

To sum up, the solution is not just to increase supply, but to focus on a Rational Use of Energy (RUE), energy conservation, and adequate Demand Side Management (DSM). Rational use of energy and energy conservation, and the need to increase energy services are not contradictory goals. This is particularly true for industrialised countries and urban areas of developing countries in activities related to transportation, industrial production, and services.

Developing countries must increase their level of energy services, i.e., their useful energy consumption, if they are to achieve sustainable human development. This calls for a massive shift in the way energy is metered especially in the developing countries like India.

SAQ 2

Distinguish between supply side and demand side management. Explain the strategies and methods that can be used to manage urban energy demand.

The **assessment** of **economic, social** and **environmental impacts** of energy production and use is an essential part of the energy planning process and requires technical expertise as well as the participation of stakeholders. It is a complex issue as you have studied in Unit 5. It has implications for the development process and therefore is context specific. Yet, as we have mentioned right in the beginning, the ultimate aim of energy planning should be to provide sustainable energy to all citizens in an equitable manner.

Research and development activities are essential for improving existing technologies and inventing new technologies, finding better practices, investigating public response to energy policies and options, etc. Scientists and engineers, architects and city/utility planners, as well as elected officials, and developers can research better practices to use energy more efficiently and in a sustainable manner.

To ensure equity of access, we also need to create **institutional mechanisms** for the participation of all stakeholders in the energy planning and implementation process as well as **monitoring** and **evaluation mechanisms**. In India, the Panchayats could be one category of grassroots organisations to participate in micro-level energy planning; energy cooperatives have been established in some parts as you will learn in Unit 8. Similarly, the Residents Welfare Associations (RWAs) can be roped in to help establish a sustainable energy supply system.

Awareness about new energy saving technologies, renewable energy options, and capacity building are important areas that require methodical planning. You must have come across the campaigns of the PCRA (Petroleum Conservation Research Association) to save energy. Comprehensive energy education programmes can be included at all levels of formal education as well as be offered through informal modes. We will weave in these issues in our discussion on urban energy planning in the next section.

Fig.7.7: Various stakeholders in the energy planning process

The roles of various stakeholders in the energy planning process is summarised in Table 7.1.

Table 7.1: The role of various stakeholders in the energy planning process

Stakeholder	Role
National Government	• Formulating the energy policy and setting energy goals for national development; • Faming regulations to facilitate fulfilment of energy goals; • Providing funds and resources for the energy sector. • Encouraging state and local governments to adopt regulations that reflect good energy planning principles; • Developing national energy database, promoting national standards for energy performance and establishing guidelines for energy efficiency; • Setting up national R & D facilities for research, development, standardisation and demonstration of energy efficient systems and technologies; • Setting up monitoring mechanisms, developing and disseminating tools and methods for monitoring energy performance and implementing energy policy; • Linking infrastructure financing to energy-related performance targets; • Providing information, financing and technical assistance on energy efficiency and supply options.
State/Local Government	• Including energy considerations in regional development strategies and plans and ascertaining energy opportunities; • Distributing information on energy options and financing to developers, builders and the people; • Commissioning energy surveys in accordance with the ongoing energy planning scenario as well as the near term projections. This will help to ascertain the willingness of the target group to share energy driven responsibilities;

	• Monitoring energy use and enforcing energy performance standards; • Developing regional energy sharing agreements.
Utilities (Related to Energy)	• Identifying energy resources; • Providing advice and technical support on energy-related issues; • Participating in planning exercises to influence community development and energy consumption patterns; • Identifying energy options and incorporating them into internal strategic and operational plans (such as Integrated Resource Plans); • Identifying potential design changes and design standards to improve service quality and cost-effectiveness.
Developers	• Identifying commercially viable local and/or renewable energy resources; • Becoming familiar with current energy opportunities and using them; • Becoming familiar with public preferences and potential market trends; • Working with local planners to identify preferred development standards or design features that can be practically implemented; • Constructing buildings and roads, etc. on the basis of their long term costs and performance and conforming to standards; • Using cost-saving or cost-neutral energy options and adopting designs and features that recognise and mitigate infrastructural and environmental constraints or costs; • Facilitate easy financing mechanisms devoid of bulky and cumbersome documentation practices of the past.
Public	• Making local governments include energy sustainability goals in official development plans; • Providing input about energy issues and options; • Making preferences for alternative neighbourhood designs known to planners and developers; • Participating in energy planning exercises; • Making purchasing decisions on the basis of "life cycle costs"; • Indicating support for reducing the cost of infrastructure and improving energy efficiency to local politicians, planners and developers.

7.4 URBAN ENERGY PLANNING

Urban areas are facing rapid expansion, with a growing demand for public infrastructure and services, pressure to accommodate new growth and preserve existing areas and a limited ability to pay. There is growing public dissatisfaction with the quality of life. There are many challenges today for urban development: creating new infrastructure and services, managing residential growth, preserving watershed quality and valued green space, controlling air pollution, mitigating traffic congestion and revitalising local economy.

As climate change pressures begin to mount, urban communities will have to look for ways of "doing their bit" to reduce the emissions of greenhouse gases. For example, one way of reducing GHG emissions would be to use mass public transport and avoid single vehicle use so that there is lesser number of vehicles on the roads emitting GHGs. The metro rail in the capital city of Delhi is a new agent of such change. This is one example. The larger question is: As we work towards long-term liveability and sustainability goals in urban areas within ever-shrinking budgets, where does energy fit in the overall urban development planning? Good energy planning, integrated into urban planning processes, can help us address many of today's challenges.

You have studied that the way we use and deliver energy affects the development and sustainability goals. Traditionally, the urban areas were designed without consideration of the energy effects and were unnecessarily wasteful of energy. Since energy has typically been delivered quite independent of the urban planning process, opportunities for innovative energy and cost-saving measures have been missed. In fact, large multi-storeyed complexes having enough glass area for heat admittance are mushrooming. These guzzle precious electrical energy showing an utter disregard for energy conservation. Since energy doesn't run through municipal or builders' considerations, energy benefits are the easiest to sacrifice!

It is now well known that decisions made about urban land use, transportation, site plans and neighbourhood design have a profound effect on energy and energy-related air emissions. The hidden costs of energy include not just the price we pay for electricity or transportation, but also land development costs, infrastructure costs, health costs and many other non-financial costs.

Politicians, planners, engineers, land developers, and most importantly the public, must recognise how much our current approach to energy is costing us – financially, environmentally and socially. We need to make use of the new approaches to **urban energy planning** that are compatible with the goals of energy planning outlined in the previous section.

Times are changing and the available energy options are changing. New opportunities are emerging in the energy sector. New small-scale energy supply technologies now offer cost-competitive choices for delivering energy at the site, neighbourhood, community and city scale. The major advantage of this arrangement is an easily accessible operation and maintenance setup.

A changing policy environment is opening up business opportunities for independent power production and distribution. This should lead to more energy choices for communities in both urban and rural areas.

Urban areas need to be developed in a manner that is compact, more sustainable and energy efficient. An example will help you understand the importance of good energy planning. Through effective land use planning, the following benefits were derived by the community of Northeast Coquitlam in Canada:

- 30% lower infrastructure capital and operating costs,
- 24% lower CO emissions,
- 20% less land covered in streets,
- 5% reduction in energy consumed for all purposes,
- 93% improvement in solar orientation of streets,
- 70% less travel distance to shopping,
- 20% increase in household proximity to parks and open space,
- 250% increase in the number of key community facilities and amenities, and
- 400% increase in local job opportunities.

Thus, energy planning is an essential requirement for comprehensive urban development. Energy-related concerns need to be integrated into overall urban planning to improve energy availability at least social and environmental costs. For this, we need to understand the complex linkages between energy, land-use planning, air quality, transportation, energy supply options and economics in urban areas.

Let us begin by listing the energy needs of urban areas.

Energy in urban areas is used mainly in the services sector, infrastructure, buildings and also in industries, if any. Some energy uses are indicated in Table 7.2. You can add to the list.

Table 7.2: Energy needs of urban areas

Services	Infrastructure	Buildings
Transport to move people and goods within the city, ***Hospitals*** and other healthcare facilities, ***Schools***, ***offices*** and other institutions, ***Markets***, ***Banks***, etc.	For delivering ***municipal goods*** and ***services*** such as ***water***, ***wastewater treatment***, ***power***, ***telecommunications***, etc.	For ***domestic tasks*** like cooking, washing, etc. , ***heating***, ***cooling***, ***equipment*** and ***appliances***, etc.

In all these areas, energy use can be influenced by planners, engineers or land developers through regional growth strategies, area-based plans and regulations, site planning, building design and laws, transportation and infrastructure plans. Energy goals must be identified explicitly, formal monitoring mechanisms and a strong communications programme developed to maintain commitment over time.

Urban energy planning involves strategies that can be applied at the local level by planners, engineers and developers in cooperation with energy suppliers (both public and private). It involves

- **Land use and transportation planning** to develop appropriate urban land use patterns, land use density and mix, to increase the availability and convenience of transportation alternatives, to make urban areas more liveable and accessible to all.
- **Site planning and building design** to increase the use of design philosophies and features that improve energy performance and enhance the quality of life.
- **Infrastructure design and efficiency** to increase the use of energy-efficient technologies or service options in infrastructure, and to increase the production of energy from regional or municipal facilities.
- **Planning for new energy supply options** to increase the use of local supply options, high efficiency supply options, and "cleaner" supply options.

Urban energy planning can be applied either comprehensively or incrementally, and it can be adapted to suit any area, small or large. **Urban Energy Planning** can result in many benefits such as:

- **Reduced traffic congestion and lesser air pollution:** Transportation (surface, air and water), the single largest source of air pollution in most urban areas, is a major consumer of energy. Transportation and traffic congestion also rank high among public concerns. Effective land use and transportation planning can help urban areas reduce congestion and air pollution. Certain "indirect" sources of urban pollution such as large shopping centres, hotels or office buildings can also be regulated. The current urban planning trends advocate denser, more compact urban areas as generally more "liveable" than sprawling suburban areas. Well designed compact areas lead to energy savings; they are interesting and safer places to walk around, (and so people do actually walk around). Denser areas have an increased viability of public transport, and so people again are coaxed out of their cars and into public areas.

- **Reduced energy demand:** Despite higher energy efficiency standards and improved technologies, energy use is bound to increase in the industrial, residential and commercial sectors of urban areas as a result of population growth. Current energy saving measures can help reduce energy demand by 10 percent to 40 percent. This not only saves money, but also helps meet air quality standards by reducing power plant emissions.

- **Conservation of water and reduced solid waste:** Reducing water consumption and solid waste generation saves the costs of energy used in water pumping and purification, waste-water treatment, water heating and waste collection, treatment and transportation.

- **Reduced cost of developing new areas:** By using fewer materials and less energy and by retrofits in older areas, urban energy planning helps reduce the cost of developing new areas too. For example, landscaping the area with vegetative cover cuts down on the net heat entering the building.

What other benefits can you think of? Write them down.

SAQ 3

Make a list of the benefits that you expect to derive from urban energy planning.

Let us now consider the aspects of urban energy planning outlined above in some detail.

7.4.1 Land Use and Transportation Planning

Land use planning and transportation strategies focus on aspects such as:

- contiguous urban development patterns;
- siting of various buildings, utilities, parking plans, etc.;
- travel reduction measures that include multi-modal road designs; and
- use of alternative fuel vehicles in public transport to reduce fuel costs and emissions.

From the energy perspective, some features of **good land use planning** being followed in planned urban development may be identified as follows:

- A mix of closely integrated land use types and densities, and more variety in housing types around strategically located **centres** that are within walking or accessible distances of residential, commercial areas and other services like schools, hospitals, etc. Density targets for future urban development; Promotion of a contiguous development pattern through staged development plans; Promotion of local employment sources;

- An inter-connected transportation network and a multi-modal street design that accommodates cars, transit vehicles, bicycles, pedestrians and high occupancy vehicles; Higher density uses directed to arterial roads and future transit routes; The role of feeder services becomes quite important in this scheme of things;

- Protection of areas of high environmental sensitivity; and

- A network of active and passive parks and leisure opportunities.

Let us elaborate on these points.

In energy friendly planned land use, strategic locations are developed as centres of residential, commercial, and civic activity. These centres may be designed to be the "heart" of complete communities within which amenities are clustered. A variety of residential types and densities within an area ensures that housing opportunities exist for a broad cross section of people in the community. Complementary land uses coexist in a single neighbourhood. Institutional, commercial, and retail uses, along with their associated range of employment opportunities, are then easily accessible to residents.

Green spaces protect and link key environmental resources, and also support a compact urban form. Avoiding unnecessary fragmentation of the urban core allows new development to be located next to existing urban areas and infrastructure.

Effective green space planning can preserve environmental resources, reduce the cost of servicing new development, and discourage dependence on single user transport. Strict urban boundaries are defined to protect productive land – agricultural land, wetlands, forests and wildlife areas – and prevent urban sprawl. However, this is more often than not disturbed by the private land developers in the name of unavoidable urbanisation.

Moderate-to-high density, mixed use centres offer energy and cost savings through reduced travel needs, better utilisation of infrastructure and increased opportunities for utilising waste heat and other alternative energy supply resources.

When new areas are built on the outskirts of the city boundaries, quite often large tracts of empty land are left between these new neighbourhoods and existing ones. This increases travel requirements, and consequently emissions and travel costs, as well as infrastructure costs for servicing such neighbourhoods. Planned new growth follows the principle of **contiguous development**.

It can be concentrated in appropriate areas adjacent to developed areas, or existing neighbourhoods can be redeveloped. Structures may be designed to accommodate present or future vertical development.

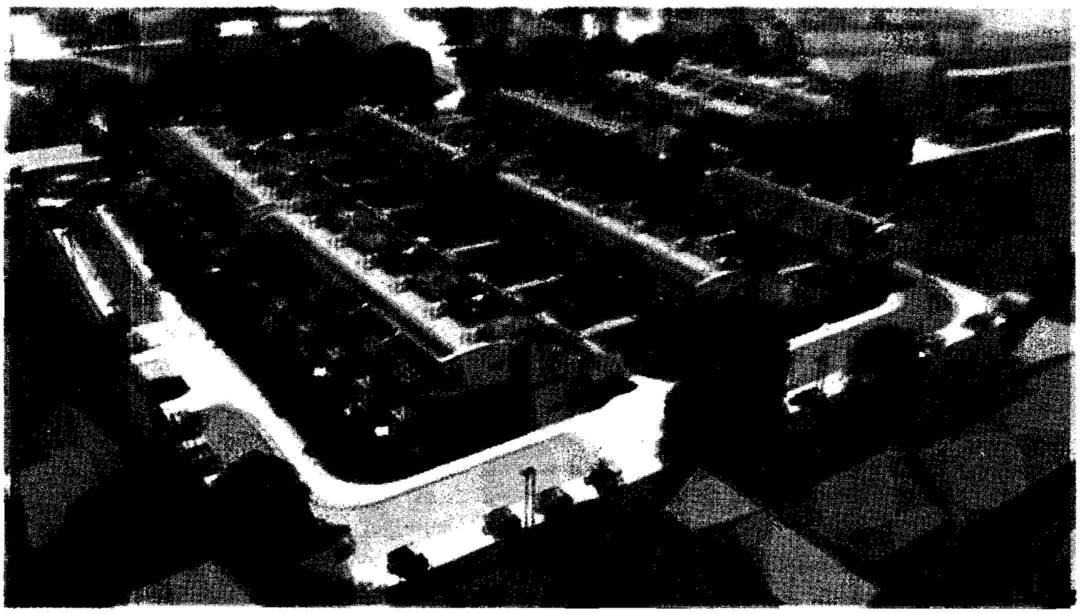

Fig.7.8: An illustration of land use planning compatible with energy planning
(**Source**: www.zedfactory.com)

The planning of gas and power distribution lines has to be coordinated with bicycle and other green corridor networks. Substantial cost savings can be realised by coordinating the timing and routes of municipal water mains, sewers, telecommunication lines and any other linear underground infrastructure with energy utility distribution systems. This, of course, requires coordination between various civic agencies.

The situation can improve if **energy performance is included as a parameter for which urban planners, engineers, and ultimately developers are held accountable**. If energy performance is to be regulated, performance-based regulation and incentives must be used rather than prescriptions. This approach also calls for faster methods of land acquisition. This is many times cited as a major reason for delay in the timely completion of large civic projects.

The creation of an efficient and reliable public transport system is an essential component of urban energy planning as single vehicle transport is extremely energy intensive and wasteful. This can be supplemented by other strategies that encourage the use of alternative energy saving options like cycling, walking to work, or using carpools, etc. Certain design measures like **multi-modal road design** help in meeting these aims. It includes the following features for transit, bicycles, pedestrians and high-occupancy vehicles, in addition to the single-occupant vehicles such as:

***Narrower Streets and Traffic Calming*:** Narrower streets, speed bumps, pedestrian corner-bulges and other such features slow or deter traffic, making streets more attractive for walking and cycling.

***Interconnected Roads Design*:** It provides more direct access throughout the area, which promotes alternatives to automobile travel. Subways, for example, in Delhi are registering the least number of foot falls owing to a variety of reasons. Energy planners entrusted with the civic works must look at the possibility of elevated pathways much closer to the bus shelters.

***Bicycle Lanes and Signals*:** The development of effective bicycle and pedestrian lanes and supportive facilities and amenities is a must. There are many different designs for bicycles lanes, from signage for designated routes to the provision of dedicated lanes.

***Bus/ Transit Lanes*:** Bus lanes and amenities such as shelters, road signs, signals, special lanes for high-occupancy vehicles and transit, which can be permanent, or designated for peak hours only, improve the usage of public transport by reducing travel time.

Preferential Traffic Rules that, for example, allow transit or high-occupancy vehicles to bypass long line-ups or left turns help in decongesting traffic.

***Roadside trees and landscaping*:** These provide shade and reduce heat absorption on roads.

A **comprehensive parking plan** complements the overall transportation strategy.

The plan should address the following features which promote energy efficiency:

- parking pricing to encourage public transport use;
- shared parking;
- preferential parking for car pools;
- parking location and design which encourages transit use and pedestrian activity;
- parking supply ratios which consider the availability of other travel options;
- differential parking rates for surface parking, underground parking and above ground parking could be administered. Time operated parking lots need to be put in place in busy areas as soon as possible.

In addition, inefficient road patterns that use unnecessary amounts of construction material due to excessive width or poor geometry should be identified. Road designs that require less road materials reduce the energy needed to produce them. The road geometry can be rationalised and the surplus road areas can be converted into developable land. A "finer" street grid with shorter blocks established in neighbourhoods encourages pedestrian travel. Also, roads oriented within 30 degrees of an east-west axis maximise the benefits of passive solar gain and optimise conditions for the use of photovoltaics.

Other measures to reduce single vehicle use include providing an optional public transport subsidy for employees, cash or passes instead of free parking as an employee benefit, pay parking for employees, a shuttle service to public transit stops, support for formation of car pools, a guaranteed ride home policy for employees who work late, telecommuting options and variable working hours.

These are some measures in land use and transportation planning that can generate significant savings in energy, bring in financial returns for the community, put the land to productive use, decongest traffic in urban areas and improve traffic patterns.

SAQ 4

How many of these features of land use and transportation planning do you see around you? Write them down.

7.4.2 Site Planning and Building Design

Site planning and building design decisions can affect energy used in buildings, transportation and infrastructure. Design features such as the number of residences within walking distance of transit, grid-like road design, the orientation of a neighbourhood to transit routes, the provision of bus shelters and amenities can all be prescribed in site development standards. Standard building designs that guarantee a minimum energy efficiency must be used.

Building design and site planning strategies focus on

- building and appliance efficiency,
- solar orientation,
- landscaping,
- wind shielding and shading,
- pedestrian facilities and orientation, and
- transit facilities and orientation.

Some of the measures are: promoting environmentally sound buildings by labelling them on the basis of their long-term cost and performance; encouraging building design and features (windows, colours) which reduce energy needs; encouraging the use of local or recycled construction materials; encouraging the installation of energy and water-efficient appliances; encouraging multi use buildings which can share energy needs; encouraging landscaping which can buffer buildings from wind and sun and help reduce heating and cooling needs; locating roads and buildings so that solar access is preserved. In addition, rainwater harvesting system should be encouraged along with the terrace garden concept for cooling of the building interiors.

More than 30% energy operating costs can be saved by conducting energy audits and investing in efficiency opportunities.

The following features can also help improve the energy efficiency in urban areas.

***Siting of public facilities*:** Public facilities such as hospitals, offices, etc. could be sited in transit-accessible mixed-use zones to ensure long term accessibility to them.

***Parking location and design*:** Parking spaces could be located behind or adjacent to buildings, or underground. This preserves transit and pedestrian access. Also, at workplaces special spaces may be established for high-occupancy vehicles in the most convenient locations. Parking lots and driveways with concrete, earth-filled blocks on perforated rubber sheets reduce cooling load on the neighbouring buildings in the summer, let grass grow through, let water sink into the ground to reduce runoff, and keep the underlying soils healthy.

***On-site Bicycle / Pedestrian Facilities*:** Secure storage must be provided for bicycles in medium-to-large commercial buildings to encourage bicycle commuting. Buildings and entrances could be oriented towards the primary pedestrian system, including links to neighbouring properties.

***On-site Carpool Facilities*:** On-site facilities for carpooling, meeting areas and transit shuttles can enhance participation in these programmes. Battery operated vehicles may be used for the common areas.

***On-Site Transit Features*:** Transit plans and building plans could be developed together to maximise convenient access and amenities at transit stops. Buildings could be oriented towards transit facilities. Transit facilities such as shelters and benches are a must. Telephones, cyber cafes, transit maps and schedules, bicycle racks and postal services located at transit stops help to make transit a more attractive travel alternative.

***Building Facades*:** Buildings located close to and oriented towards sidewalks add interest to pedestrian travel. The building line could be varied with offsetting walls, awnings, textures, and especially, entrances and windows.

***Building, Equipment and Appliances Strategies*:** There are many building design features and equipment and appliance choices that improve energy efficiency, e.g., in building envelope design standards for air tightness, insulation and windows; in heating, ventilating and air conditioning equipment and operation; lighting appliances and controls; water heating options; energy efficient appliances; mechanical heat recovery systems, etc. These also include elements such as orientation, glazing, insulation, vegetation shading, efficient lamps, and so on. There are now experimental building designs that simply use the evaporative power of the wind to cool offices, saving most of the fans, blowers and air conditioners, as well as their power use.

Incentives and bonuses could be provided to developers to include energy efficient design, or renewable or on-site energy supply options by allowing increased density of housing in exchange for meeting energy supply or efficiency targets. Bonuses can also be offered in exchange for the provision of amenities such as well designed bus shelters, cycling paths, etc. This calls for category wise rating of the energy efficient buildings as well as the public utility areas.

Some additional site and building energy options include:

***Landscaping*:** Attractive landscaping creates interest and can be used to buffer pedestrian pathways from moving traffic. It can also create shading or windbreaks in areas where summer heat or winter winds are a deterrent to pedestrian travel. Strategic landscaping buffers buildings from wind and sun, and can significantly reduce heating and cooling needs at low cost. Effective use of micro-climate (landscaping, wind shielding and shading) can save 5 to 10% of building heating and cooling costs.

***Solar orientation*:** Buildings on a site could be located so that solar access is preserved. For example, the longest facade of the building could be presented to the south (in the Northern Hemisphere). Simply re-orienting a new building to take advantage of solar energy would save 10 to 15% of the building energy costs every year. Passive solar heating can provide 30 to 60% or more of space heating needs depending on the building design.

***Day lighting*:** Most of the light that comes through office windows is converted to heat that then, together with the electric lights, loads down the cooling system. Intelligent design and advanced windows can simultaneously reduce electric lighting requirements, provide non-glare, full spectrum task lighting and save energy in building cooling. To tap even greater savings, we can design buildings that require little or no electrical lighting in the daytime. It is cheaper to construct and operate an energy efficient building that maximises sunlight than it is to use conventional design approaches and pay the resulting electricity bills. There is an undeniable need to work out the illumination requirements of each working area(s) instead of simply fixing the light fixtures at random.

Lighting is just the beginning. Creating comfortable indoor climates leads to many money-saving opportunities. Well-insulated buildings that are heated by the sun or cooled by natural means are more efficient and cost-effective than heating with electricity or using air conditioners. Such buildings are also more pleasant and healthy places in which to live or work. Since electricity is a highly refined energy source, using it to provide heat is like using a heavy truck as a personal car.

***Reflectivity*:** The colour of a building and its surroundings influences its energy use significantly. Dark surfaces create excess heat in summer, loading down air conditioners, which then add to the uncomfortable heat outside. In a cold, sunny climate, dark buildings absorb heat in the winter.

***Local and resource-efficient construction materials*:** The use of local or recycled construction materials reduces energy used in transporting and manufacturing materials. It may also stimulate local business in materials collection, distribution and retail.

***Water-efficient appliances and appliance controls*:** Water conserving appliances lead to energy savings in water pumping (in infrastructure).

SAQ 5

How many of the features mentioned in the discussion so far have you come across in the buildings and sites around you? You may like to mention them here.

7.4.3 Infrastructure Efficiency Strategies

Infrastructure efficiency strategies are related to, for example:

- power and water supply and use,
- wastewater collection and storm drainage,
- solid waste management, recycling facilities, and
- joint infrastructure planning and delivery.

Power and water conservation are the principal energy saving strategies in energy supply and use. Electricity is used for many activities in urban areas. Energy is used to pump (and heat) water and to convey and treat wastewater. Reducing the demand for electricity and water will reduce energy costs and associated emissions for power, water and wastewater infrastructure. For example, low-flow showerheads and low volume flushing systems reduce energy bills, and also save on expenditures for new water supply and treatment infrastructure. If all departments calculate their collective energy bills, and collaborate to figure out what energy conservation measures will mean to water and wastewater costs, then joint planning and financing opportunities may emerge.

The costs to deliver power and water include both the costs of operation and the costs of expansion. Therefore, these reductions may defer the need to expand existing facilities, resulting in further energy and cost savings. A comprehensive power and water conservation programme should be implemented in the mission mode. For example, use of efficient electrical appliances must be promoted; rainwater harvesting and waste water recycling is now mandatory in building design in cities like Delhi. The need is to enforce these measures.

Roads should be designed to facilitate the collection of storm water instead of allowing it to drain away. Energy efficiency experts can help identify other energy and cost-saving opportunities. The general perception is that major losses take place in transmission and distribution of electricity and little concern is shown for water leakage through pipelines. For example, Delhi loses around 40% of its piped water resources, which represents colossal loss in terms of energy usage and is a matter of grave concern.

Recycling and re-use can be encouraged by setting up required infrastructure and by creating awareness and training for composting, industrial and white goods collection and recycling. For example, waste polystyrene – coffee cups, boxes and packing material – can be used to make high-quality thermal and noise insulation for homes. It has been in wide use in Europe, Asia and the Middle East for years. Polystyrene is completely non-biodegradable and would otherwise just sit in landfills. Proven technologies exist for urban solid waste management for energy recovery and energy supply.

All measures must be taken to reduce the volume of goods going to the landfill. Thus the energy costs of transporting them there would also be reduced. Re-use programmes reduce the consumption of goods in the first place. Since energy is used to produce those goods, re-use programmes also save energy. Energy savings should be included in cost-benefit analyses for recycling and re-use strategies.

The introduction of **direct user fees** by civic agencies for services such as solid waste collection, water supply and wastewater treatment will not only provide a means of recovering costs without raising taxes, but will encourage consumers to balance their needs with the real costs of the service. Reductions in demand can be expected, which will lead to energy and cost savings, both for operational expenses and future capital expenditures.

7.4.4 Alternative Energy Supply

Urban energy planning encourages the development of other energy supply options such as the following:

Multi-use buildings and waste heat utilisation: Many commercial activities are net generators of heat, while residences are net heat users. Mixed uses within a building, especially with commercial uses on the ground floor and residential units above, are favourable for saving energy. Multiple uses even out heat and power needs over time, increasing the viability of on-site energy supply. Mature technologies are now available for simultaneously producing heat and power in stand-alone units, which can be installed on the site. Systems can be owned and operated by developers, building owners, or energy service companies as a revenue generating venture or by owner/tenant cooperatives as a community based cost-saving initiative.

At the community or neighbourhood level, there are a number of energy supply strategies such as **micro-cogeneration of heat and power**, **waste heat utilisation, heat pumps**, **heat and power from sewage facilities or local industry and District Energy systems** that should be considered by planners, engineers and developers. Some of them could provide unique revenue generating opportunities. Municipalities, regions, or land and building developers can produce and sell heat and power to a discrete group of tenants or owners – and make a profit in the process!

Cogeneration is the simultaneous production of power and usable heat (see Fig.7.9). In conventional power plants, a large amount of heat is produced but not used. By designing systems that can use the heat, the efficiency of energy production can be increased from current levels that range from 35-55%, to over 80%. New technologies are making cogeneration cost-effective at smaller and smaller scales, meaning that electricity and heat can be produced for neighbourhoods or even individual sites.

Micro-cogeneration refers to systems that produce heat and power at site scale – for individual buildings or building complexes.

Heat pumps move heat around without creating new heat, just like a refrigerator. They can heat or cool a building, reversibly. Although they do require electricity, they typically move about three times as much energy as they use. A heat pump can use the ground, air or river or ground water as a source of heat. It is a highly adaptable, proven and energy-efficient technology. It can be built to the scale of an individual house, to suit a large building or to provide heat to larger urban communities.

Methane from anaerobic decay can be tapped, gathered and used for power generation at landfill sites. Landfill gas projects use standard technology to generate useful heat and power. Not only is energy produced, but greenhouse gas emissions are reduced, as methane releases from landfills are a significant contributor to the climate change problem. **Sewage gas** can be used for generating combined heat and power at

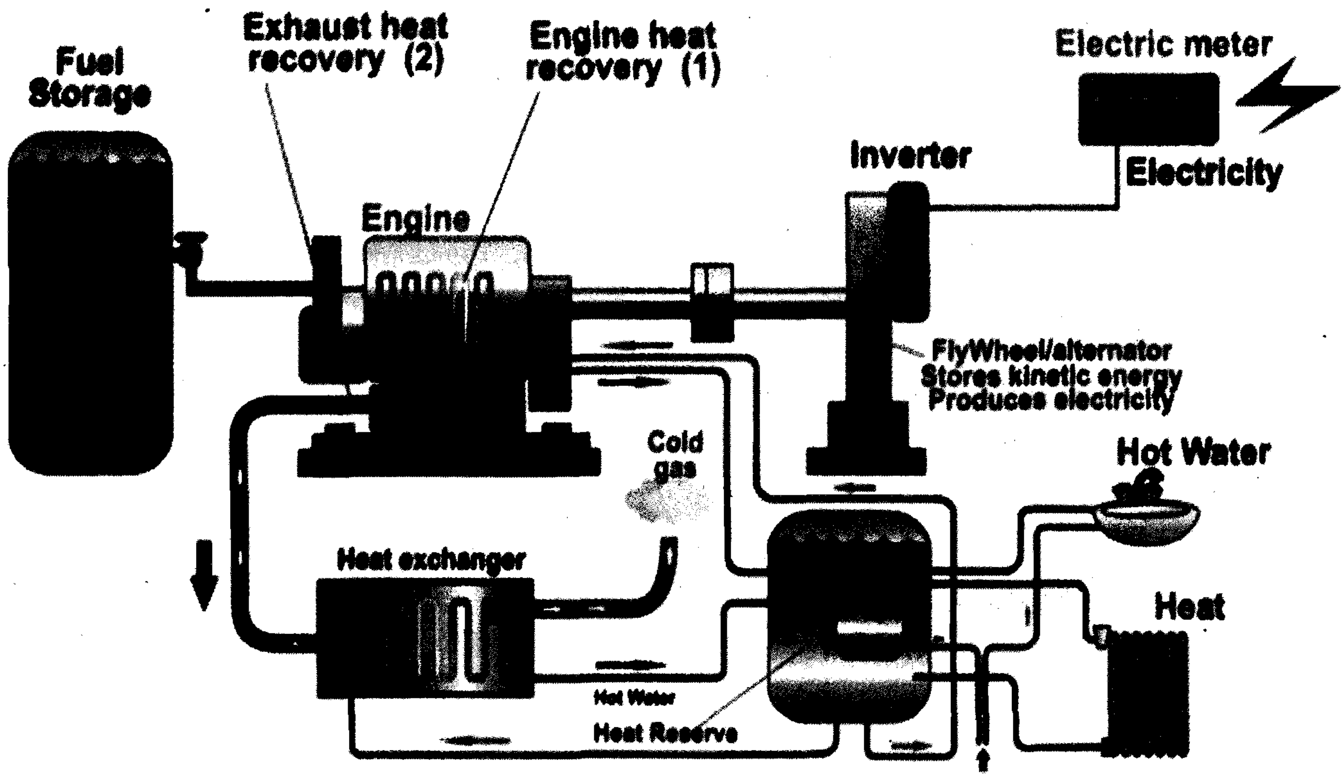

Fig.7.9: A typical co-generation system (Source: www.energiestro.com)

sewage treatment facilities. Costs for small, natural gas-fired turbines and reciprocating engines / generators have been dropping in recent years. Most communities over 40,000 in population have sewage treatment facilities suitable for power production. Heat pumps can take the waste heat from sewage trunk lines to create useful heat sources for district heating systems.

Industrial facilities (such as pulp mills and other large industrial plants) close to urban areas generate large quantities of residual heat that may be recovered and used productively. Recent plastic piping technology enables relatively long-range transport of low-pressure steam and hot water, with minimal heat loss.

District Energy Systems are multi-building heating and cooling systems. Some district energy systems are cogeneration systems, i.e., they produce both usable heat and electricity. Heat is distributed by circulating hot water (or low pressure steam) through underground piping. Some systems also include district cooling. The source of energy for district heating systems is usually a steam boiler, typically fired by natural gas, although other sources are possible. Hybrid systems, using a combination

A **fuel cell** is an electricity generator that produces an electric current by combining fuel and oxygen in an electrochemical reaction. Fuel cells are efficient, clean and can run on a variety of fuels, including natural gas and hydrogen. Because they produce electricity directly (while conventional generators must burn the fuel and use the heat to turn a shaft), even those that run on natural gas (a fossil fuel) are a "clean" energy alternative. They have very high efficiency over a wide range of operating conditions. They are quiet, very easy to site, have low maintenance costs, and can be built to almost any size by linking cells in a stack. Most types also produce useful heat that can be used for space or water heating, or in some cases, for further power generation. Commercial fuel cells have been running for many years. Their noise levels are approximately the same as average street noise.

of natural gas, wood waste, municipal solid waste and waste heat from industrial sources are possible, and often more economical. District energy system technologies are standard and in common use in developed countries. Because they use waste heat, either from an existing boiler that is currently venting excess heat, or from electricity generation facilities, they are more efficient, cleaner and often more cost-effective than conventional supply systems.

Technology options for co-generation and District Energy to generate heat and power for use at the community, neighbourhood or site level include **fuel cells, small-scale generators** including gas turbines and small internal combustion engines; their costs have been dropping steadily and they are now available at increasingly small scale. From the perspective of air emissions and environmental protection, gas-fired combined-cycle plants are efficient, modern and reliable. Dispersion of the air pollutant emissions is such that impacts at residential points (open spaces, streets, buildings) are minimal. These generators can be housed in self-contained units located in building basements or utility sheds. **Renewable energy technologies** like photovoltaics, solar thermal devices, solar passive design, wind turbines, small-scale hydro, wood "waste", etc. are also becoming viable. You will study about them in detail in Block 4.

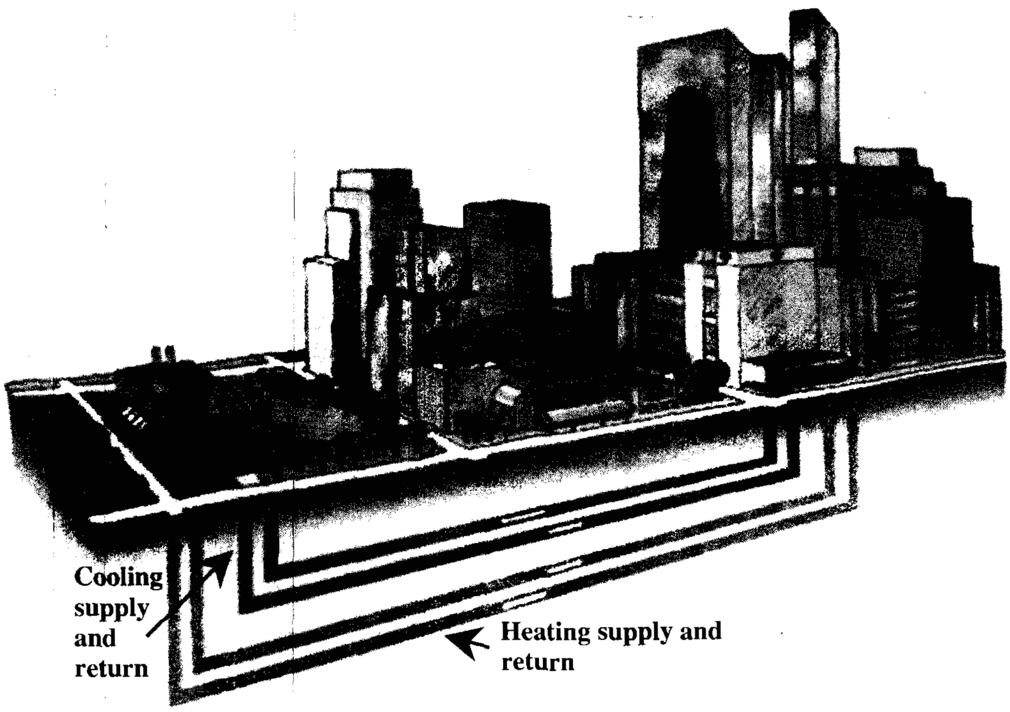

Fig.7.10: District energy system (**Source**: www.districtenergy.org/)

So far, we have given you a bird's eye view of the immense possibilities that exist for saving energy through urban energy planning. Sustainability principles are as relevant to local systems as to global ones. For example we might talk about "sustainable cities" or even "sustainable buildings". The question is: What can we do in our individual capacity and at the community level to help in this effort?

7.4.5 Community Energy Planning: What You Can Do

Today, we are faced with rising fuel and electricity costs, accompanied by shortages and unreliability of supply. Besides, there are local pollution problems. Can we do something about the situation? Local energy planning can help us meet local needs. For example, in India, individuals and local communities in Karnataka and Uttaranchal have installed micro-hydro plants to meet their energy needs. Any single energy-related issue can be a catalyst for local involvement in energy planning. Often this can be a good way of getting started, especially for smaller communities and individuals.

One way of going about this is to **match various tasks with the appropriate kind of energy and then use that energy as efficiently and cost-effectively as possible.** This can lead to significant savings in all end-uses. We can save more than half of all energy used to cool and heat our buildings, heat water, cook, heat and refrigerate food, and run motors for various processes by improving energy efficiency.

For example, ask yourself: How do you meet your lighting needs? The use of available options like CFLs, sensors to dim lights or bring them on as needed, add up to big results as the lighting bills can be reduced by up to 90 percent, while improving lighting quality. It also improves the working conditions noticeably that result in reduced absenteeism and increased productivity.

SAQ 6

In what ways can you save energy in your home and your work place? Make a list of the things you would like to do to save energy.

The end-use/least cost approach for delivering energy services has many economic benefits. For example, the use of more efficient buildings, computers, appliances, automobiles and factories reduced energy expenditures by more than $150 billion a year since 1973 levels in the USA. While part of this energy bill reduction is because the American economy shifted from manufacturing to services, at least 75 percent of these savings are due to increased energy efficiency. Far greater savings can be tapped. It is estimated that lighting improvements could save as much as 50 percent of all electricity used for lighting across USA. These energy savings would allow consumers nationwide to save $18.6 billion on their utility bills, free up $60 billion for other economic purposes, avoid the cost of building new power plants, and prevent 200 million tons of carbon dioxide from entering the atmosphere.

You can draw the energy profile of your home, work place or community. Find out how much energy is being used, where it comes from, how much it costs and how it affects the local and the global environment. There are sophisticated modelling tools that can help you do this. But you can also do a "back-of-the-envelope" calculation. Precise measurements are not essential; a broad understanding of the collective impact of energy use patterns on the individual or the community is. Then explore where you can save energy or improve energy use efficiency.

Set goals and make an action plan. Design and implement simple, high-visibility projects. This helps to build momentum. Monitor the results. Define **indicators** to measure progress toward goals. Set targets and assign accountability for achieving them. Use monitoring results to identify which strategies are working and which ones are not. Use this information to revise the action plan if necessary. Find ways to provide feedback to the community and to celebrate success.

Many community energy planning strategies cost little or nothing, such as alternative land use planning approaches, certain building design features or educational initiatives. Others, like retrofits in municipal buildings or local energy systems, save money in the long term, but have initial costs. These require financing. Financing means finding money. You could try various options such as joint ventures, public-public and public-private partnerships, third-party financing, e.g., by Energy Service Companies Energy Service Companies, or ESCOs, (private firms that offer technical and financing services for energy supply and efficiency investments). Financial institutions, banks, trust companies and credit unions are starting to develop energy efficiency-related financial services.

All the best technical tools and strategies will be ineffective if the public is not aware of, involved with, and committed to the community energy planning process.

You can take the message to the community. Once you know the current costs of energy services, spread the message about the benefits of an alternative approach. Make sure elected representatives and civic officials understand how energy relates to other priorities. Make energy a high-profile issue in your community, build energy into public involvement and help in developing energy education programmes that have been developed for other planning issues. Public meetings and open houses are good ways of providing information to the public and getting feedback on development proposals. You could organise workshops, form focus groups to provide feedback on a specific issue and use the meeting to gauge the likely response of a broader group. Get strong, committed individuals to champion successful community energy strategies.

Take the message to energy and water utilities, large energy users, small business representatives, residents' associations, land and building developers, financing institutions, independent power producers, energy service companies, equipment and appliance dealers and senior government agencies. Review success stories in other communities and develop local ideas. Most enterprises, small and large, are looking for opportunities to save money. Sometimes just by providing information on cost-saving opportunities, businesses become leaders and catalysts of change. Organise programmes for local businesses and developers; your community could institute "green business" awards for innovative businesses that achieve significant energy and other resource savings. Look for ways to disseminate "best practices" and to support green business and industry networks.

We have put forth a few ideas to set you thinking. You could generate a host of other innovative strategies and plans of action. With this we end the discussion on energy planning and present a summary of the unit contents.

7.5 SUMMARY

- **Energy planning** is the process of envisioning a desired future state of sustainable energy supply and consumption based on existing concerns and realities, and designing the appropriate measures to implement that energy future. It helps in creating a picture of the current energy situation and estimated future energy needs based on expected patterns of development.

- The broad **aims** of macro-level energy planning include providing the basis for framing **the energy policy**, helping **find and allocate resources** for **meeting specific energy requirements**/demand of all sectors in an optimal manner, helping improve energy performance, and enhancing the quality of life, promoting the development and use of new, high efficiency, "cleaner" supply options and energy-efficient technologies.

- The **energy planning process** consists of data base development, supply and demand analysis, assessment of economic, social and environmental impacts, creation of research and development facilities, creation of institutional mechanisms for the participation of all stakeholders in the planning and implementation process, implementing schemes for awareness generation, capacity building and educational programmes, setting up monitoring, follow up and evaluation mechanisms.

- **Urban energy planning** involves **land use and transportation planning, site planning and building design, infrastructure design and efficiency**, and **planning for new energy supply options**.

- Communities and individuals can play a very important role in the energy planning process by adopting energy conservation practices and popularising them.

7.6 TERMINAL QUESTIONS

1. What do you understand by energy planning? Discuss its relevance for developing countries.

2. Explain the process of energy planning in the context of your locality/region. Which steps in this process need to be worked upon to meet the goals of energy planning in your context?

3. Analyse the role of individuals, governments and local institutions in community energy planning.

4. Identify a set of activities that you can carry out to improve the energy situation around you. Make a plan of action and try to implement it.

5. Outline the main drawbacks of a faulty energy planning.

6. Can energy planning be done in at the household level?