UNIT – II

ENERGY CONSERVATION PRINCIPLE

ENERGY CONSERVATION

Energy conservation is the effort made to reduce the consumption of energy by using less of an energy service. This can be achieved either by using energy more efficiently (using less energy for a constant service) or by reducing the amount of service used (for example, by driving less). Energy conservation is a part of the concept of Eco-sufficiency. Energy conservation measures (ECMs) in buildings reduce the need for energy services and can result in increased environmental quality, national security, personal financial security and higher savings. It is at the top of the sustainable energy hierarchy. It also lowers energy costs by preventing future resource depletion.

Energy can be conserved by reducing wastage and losses, improving efficiency through technological upgrades and improved operation and maintenance. On a global level energy use can also be reduced by the stabilization of population growth.

Energy can only be transformed from one form to other, such as heat energy to motive power in cars, or kinetic energy of water flow to electricity in hydroelectric power plants. However machines are required to transform energy from one form to other. The wear and friction of the components of these machine while running cause losses of very high amounts of energy and very high related costs. It is possible to minimize these losses by adopting green engineering practices to improve life cycle of the components.

Energy conservation day is celebrated on December 14 every year since 1991.

Energy conservation is important and beneficial for many reasons. You can save money, increase your property value, and protect the environment all through simple energy-saving measures. These are great benefits you can gain from saving energy no matter your exact motivation for conservation in the first place. By simply taking a small step towards living a more energy-conscious lifestyle, you can begin to enjoy all of the perks of being energy efficient.

Technologies for energy conservation:

There are many different ways to reduce your household’s energy use, ranging from simple behavioral adjustments to extensive home improvements. The two major motives for conserving energy are to save on utility bills and protect the environment. Here are the ten most common ways to conserve energy and save electricity in your home, listed from the simplest to the most intensive methods.

1. Adjust your day-to-day behaviors

To reduce energy consumption in your home, you do not necessarily need to go out and purchase energy efficient products. Energy conservation can be as simple as turning off lights or appliances when you do not need them. You can also use energy-intensive appliances less by performing household tasks manually, such as hang-drying your clothes instead of putting them in the dryer, or washing dishes by hand.

The behavior adjustments that have the highest potential for utility savings are turning down the heat on your thermostat in the winter and using your air conditioner less in the summer. Heating and cooling costs constitute nearly half of an average home's utility bills, so these reductions in the intensity and frequency of heating and cooling offer the greatest savings.

There are tools you can use to figure out where most of your electricity is going in your home and which appliances are using the most electricity on a day-to-day basis.

2. Replace your light bulbs

Traditional incandescent light bulbs consume an excessive amount of electricity and must be replaced more often than their energy efficient alternatives. Halogen incandescent bulbs, compact fluorescent lights (CFLs), and light-emitting diode bulbs (LEDs) use anywhere from 25-80 percent less electricity and last 3 to 25 times longer than traditional bulbs.

Although energy efficient bulbs are more expensive off the shelf, their efficient energy use and longer lifetimes mean that they cost less in the long run.

3. Use smart power strips

"Phantom loads," or the electricity used by electronics when they are turned off or in standby mode, are a major source of energy waste. In fact, it is estimated that 75% of the energy used to power household electronics is consumed when they are switched off, which can cost you up to $200 per year. Smart power strips, also known as advanced power strips, eliminate the problem of phantom loads by shutting off the power to electronics when they are not in use. Smart power strips can be set to turn off at an assigned time, during a period of inactivity, through remote switches, or based on the status of a "master" device.

4. Install a programmable or smart thermostat

A programmable thermostat can be set to automatically turn off or reduce heating and cooling during the times when you are asleep or away. When you install a programmable thermostat, you eliminate wasteful energy use from heating and cooling without upgrading your HVAC system.

On average, a programmable thermostat can save you $180 per year. Programmable thermostats come in different models that can be set to fit your weekly schedule. Additional features of programmable thermostats can include indicators for when to replace air filters or HVAC system problems, which also improve the efficiency of your heating and cooling system.

5. Purchase energy efficient appliances

On average, appliances are responsible for roughly 13% of total household energy use. When purchasing an appliance, you should pay attention to two numbers: the initial purchase price and the annual operating cost. Although energy efficient appliances might have higher upfront purchase prices, their operating costs are often 9-25% lower than conventional models.

When purchasing an energy efficient appliance, you should look for appliances with the ENERGY STAR label, which is a federal guarantee that the appliance will consume less energy during use and when on standby than standard models. Energy savings differ based on the specific appliance. For example, ENERGY STAR certified clothes washers consume 25% less energy and 45% less water than conventional ones, whereas ENERGY STAR refrigerators use only 9% less energy.

6. Reduce your water heating expenses

Water heating is a major contributor to your total energy consumption. Other than purchasing an energy efficient water heater, there are three methods of reducing your water heating expenses: you can simply use less hot water, turn down the thermostat on your water heater, or insulate your water heater and the first six feet of hot and cold water pipes.

If you are considering replacing your water heater with an efficient model, you should keep in mind two factors: the type of water heater that meets your needs and the type of fuel it will use. For example, tankless water heaters are energy efficient, but they are also a poor choice for large families as they cannot handle multiple and simultaneous uses of hot water. Efficient water heaters can be anywhere between 8% and 300% more energy efficient than a conventional storage water heater.

7. Install energy efficient windows

Windows are significant source of energy waste - they can add up to 10-25% of your total heating bill. To prevent heat loss through your windows, you can replace single-pane windows with double-pane products instead.

For homes in colder regions, gas-filled windows with “low-e” coatings can significantly reduce your heating expenses. In addition, interior or exterior storm windows can reduce unnecessary heat loss by 10 to 20 percent. You should especially consider storm windows if your region experiences frequent extreme weather events.

In warmer climates, heat gain through windows may be a problem. In addition to minimizing heat loss, low-e coatings on windows can reduce heat gain by reflecting more light and lowering the amount of thermal energy that enters your home. Depending on where you live, ENERGY STAR windows can save you $20-$95 each year on your utility bills. Window shades, shutters, screens, and awnings can also provide an extra layer of insulation between your home and outside temperatures, leading to even more energy conservation.

8. Upgrade your HVAC system

An HVAC system is composed of heating, ventilation, and air conditioning equipment. Heating alone is responsible for more than 40% of home energy use. Because homes in Northern regions are exposed to much colder temperatures during the year, ENERGY STAR gas furnaces have different specifications in the northern and southern halves of the United States.

Upgrading to a “U.S. South” ENERGY STAR certification can save you up to 12% on your heating bill, or an average of $36 per year. ENERGY STAR furnaces in the northern half of the U.S. are labeled with the standard ENERGY STAR logo and are up to 16% more energy efficient than baseline models. This translates to average savings of $94 per year on your heating bill in the Northern U.S.

Air conditioning, by comparison, isn’t a significant contributor to energy bills – on average, it only makes up six percent of the total energy use of your home. ENERGY STAR central air conditioning units are eight percent more efficient than conventional models. Air conditioning systems are usually integrated with heating systems, which means that you should purchase your new furnace and air conditioner at the same time in order to ensure that the air conditioner performs at its maximum rated energy efficiency.

Upgrades to the third component of an HVAC system – ventilation – can also improve your energy efficiency. A ventilation system is composed of a network of ducts, which distributes hot and cold air throughout your home. If these ducts are not properly sealed or insulated, the resulting energy waste can add hundreds of dollars to your annual heating and cooling expenses. Proper insulation and maintenance on your ventilation system can reduce your heating and cooling expenses by up to 20%.

9. Weatherize your home

Weatherizing, or sealing air leaks around your home, is a great way to reduce your heating and cooling expenses. The most common sources of air leaks into your home are vents, windows, and doors. To prevent these leaks, you should ensure that there are no cracks or openings between the wall and vent, window, or doorframe.

To seal air leaks between stationary objects, such as the wall and window frame, you can apply caulk. For cracks between moving objects, such as operable windows and doors, you can apply weather stripping. Weather stripping and caulking are simple air sealing techniques that typically offer a return on investment in less than a year. Air leaks can also occur through openings in the wall, floor, and ceiling from plumbing, ducting, or electrical wiring.

Air leaking out of your home is most often from the home interior into your attic through small openings. Whether it is through ducts, light fixtures, or the attic hatch, hot air will rise and escape through small openings. As the natural flow of heat is from warmer to cooler areas, these small openings can make your heating bill even higher if your attic is not sufficiently insulated. To reap the full amount of savings from weatherization, you should consider fully insulating your home.

10. Insulate your home

Insulation plays a key role in lowering your utility bills through retaining heat during the winter and keeping heat out of your home during the summer. The recommended level of heat resistance, or “R-value,” for your insulation depends on where you live. In warmer climates, the recommended R-value is much lower than for buildings located in colder regions like the Northeast.

The level of insulation you should install depends on the area of your house. Your attic, walls, floors, basement, and crawlspace are the five main areas where you should consider adding insulation. Use the Home Energy Saver tool for recommendations based on the specifications of your home, or find general regional recommendations on the Department of Energy's webpage on insulation.

Energy Scenerio:

1. Classify the types of the energy available on the earth?

Ans. Energy can be classified into several types based on the following criteria as:

• Primary and Secondary energy

• Commercial and Non commercial energy

• Renewable and Non-Renewable energy

2. Briefly mention about primary sources of energy?

Ans. Primary energy sources are those that are either found or stored in nature. Common primary energy sources are coal, oil, natural gas and biomass. Other primary energy sources found on earth include nuclear energy from radioactive substances, thermal energy stored in earth's interior and potential energy due to earth's gravity.

3. What is renewable energy and list at least three renewable energy sources?

Ans. Renewable energy is the energy obtained from sources that are essentially inexhaustible but has limited potential for exploitation. Examples of renewable resources include wind power, solar power, geothermal energy, tidal power and hydro electric.

4. Name the five states in India, where coal production is concentrated.

Ans. Coal production is concentrated in Andhra Pradesh, Bihar, Madhya Pradesh, Maharashtra, Orissa, Jharkhand and West Bengal.

5. Define Reserve to 'Production Ratio'?

Ans. It is the ratio of fuel reserves remaining at the end of the year to the production in that year.

6. How do you define 'Final Energy Consumption'?

Ans. Final energy consumption is the actual energy demand at the user end. This is the difference between primary energy consumption and the losses that takes place in transport, transmission, distribution and refinement.

7. Why developed countries have been able to maintain low ratio of energy to GDP?

Ans. This is because they have been able to focus on two important issues like, energy efficiency and lower energy intensity routes.

8. What is Energy intensity and what it indicates?

Ans. Energy intensity is energy consumed per unit of GDP and it indicates the development stage of that country.

9. Mention the parameters on which the high tension and low tension consumers are charged by electricity boards.

Ans. Generally, high tension consumers are charged based on both demand (kVA) and energy (kWh) while the low tension consumers are charged based on only energy consumed (kWh).

10. What is main objective of Electricity Act, 2003?

Ans. The main objective of Electricity Act, 2003 is to create liberal framework of development for the power sector by distancing Government from regulation.

11. List down the major sources of pollutants in Air?

Ans. The major sources of pollutants in Air are fuel combustion in transport, industry, forest fires, and solid waste disposal.

12. What is greenhouse gas effect?

Ans. The heating up of earth's atmosphere due to trapping of long wavelength infrared rays by the carbon di-oxide layer in the atmosphere is called green house effect.

13. What are the key greenhouse gases driving global warming?

Ans. Carbon-dioxide, CFC, methane, Ozone, Nitrous oxide etc.

14. What are the two major anthropogenic causes for the generation of Carbon dioxide in the atmosphere?

Ans. 1. Combustion of fossil fuels 2. Changes in land use

15. List down at least three effects of acid rain?

Ans. The effects of acid rains are as follows: Œ

- Acidification of lakes, streams and soils. Œ
- Direct and indirect affects (release of metals, for e.g. aluminium which washes away plant nutrients)
- Killing of wild life.
- Decay of building materials, paints, statues and sculptures.
- Health problems (respiratory, burning skin and eyes).

16. What is the basis for aim of Energy Security for any country?

Ans. The basic aim of energy security for a nation is to reduce its dependency on the imported energy sources for its economic growth.

17. Differentiate between Energy Conservation and Energy Efficiency?

Ans. Energy conservation is achieved when growth of energy consumption is reduced, measured in physical terms. Whereas the energy efficiency is achieved when energy intensity in a specific product, process or area of production is reduced without affecting output, consumption or comfort levels.

18. How a nation benefits from Energy Efficiency programs?

Ans. Through energy efficiency, energy imports will be reduced, which helps in conserving limited resources and lead to improved energy security.

19. How Bureau of Energy Efficiency (BEE) facilitates energy efficiency programs in India?

Ans. BEE facilitates Energy efficiency programs in India by preparing standards and labels of appliances, developing a list of designated consumers, specifying certification and accreditation procedures, preparing building codes, maintaining central EC fund and undertaking promotional activities in coordination with centre and state level agencies.

20. List down at least five designated consumers specified by the BEE?

Ans. Aluminium, Fertilizers, Iron and Steel, Cement, Pulp and Paper etc.,

21. List the strategies for better energy security of the nation?

Ans. Some of the strategies that can be used to meet future challenges to Nation's energy security are: • Building stockpiles

• Diversification of energy supply sources
• Increased capacity of fuel switching
• Demand restraint
• Development of renewable energy sources
• Energy efficiency
• Sustainable development

22. Mention some of the long-term energy strategies available for the better energy secured nation?

Ans. •Efficient generation of energy resources

• Efficient production of coal, oil and natural gas
• Reduction of natural gas flaring
• Improving energy infrastructure
• Building new refineries
• Creation of urban gas transmission and distribution network
• Maximizing efficiency of rail transport of coal production.
• Building a new coal & gas fired power stations.
• Maximizing efficiency of rail transport of coal production.
• Building new coal and gas fired power stations.
• Enhancing energy efficiency
• Improving energy efficiency in accordance with national, socio-economic, and environmental priorities
• Promoting of energy efficiency and emission standards
• Labeling programmes for products and adoption of energy efficient technologies in large industries
• Deregulation and privatization of energy sector
• Reducing cross subsidies on oil products and electricity tariffs
• Decontrolling coal prices and making natural gas prices competitive
• Privatization of oil, coal and power sectors for improved efficiency.

• Investment legislation to attract foreign investments.

• Streamlining approval process for attracting private sector participation in power generation, transmission and distribution

23. How do an Industry, nation and globe would benefit from energy efficiency programs?

Ans. Energy efficiency benefits for industry, nation and globe are as follows:

Industry:

• Reduced energy bills

• Increased competitiveness

• Increased productivity

• Improved quality

• Increased profits

Nation:

• Reduced energy imports

• Avoided costs can be used for poverty reduction

• Conservation of limited resources

• Improved energy security

Globe:

• Reduced GHG and other emissions

• Maintains a suitable environment

24. How energy pricing is done in India?

Ans. ***Coal:***

Grade wise basic price of coal at the pithead excluding statutory levies for runof-mine (ROM) coal are fixed by Coal India Ltd from time to time. The pithead price of coal in India compares favourably with price of imported coal. In spite of this, industries still import coal due to its higher calorific value and low ash content.

Oil:

As part of the energy sector reforms, the government has attempted to bring prices for many of the petroleum products (naphtha, furnace oil, LSHS, LDO and bitumen) in line with international prices. The most important achievement has been the linking of diesel prices to international prices and a reduction in subsidy. However, LPG and kerosene, consumed mainly by domestic sectors, continue to be heavily subsidised. Subsidies and cross-subsidies have resulted in serious distortions in prices, as they do not reflect economic costs at all in many cases.

Natural Gas:

The government has been the sole authority for fixing the price of natural gas in the country. It has also been taking decisions on the allocation of gas to various competing consumers.

Electricity:

Electricity tariffs in India are structured in a relatively simple manner. While high tension consumers are charged based on both demand (kVA) and energy (kWh), the low-tension (LT) consumer pays only for the energy consumed (kWh) as per tariff system in most of the electricity boards. In addition to the base tariffs, some of the State Electricity Boards have additional recovery from customers in form of fuel surcharges, electricity duties and taxes.

25. Briefly describe the economic reforms in Coal, oil and natural gas and electricity sectors.

Ans. Since the initiation of economic reforms in India in 1991, there has been a growing acceptance of the need for deepening these reforms in several sectors of the economy, which were essentially in the hands of the government for several decades. It is now been realized that if substance has to be provided to macroeconomic policy reform, then it must be based on reforms that concern the functioning of several critical sectors of the economy, among which the infrastructure sectors in general and the energy sector in particular, are paramount.

Coal

The government has recognized the need for new coal policy initiatives and for rationalization of the legal and regulatory framework that would govern the future development of this industry. One of the key reforms is that the government has allowed importing of coal to meet our requirements. Private sector is now allowed to participate in the extraction and marketing of coal. The ultimate objective of some of the ongoing measures and others under consideration is to see that a competitive environment is created for the functioning of various entities in this industry. This would not only bring about gains in efficiency but also effect cost reduction, which would consequently ensure supply of coal on a larger scale at lower prices. Competition would also have the desirable effect of bringing in new technology, for which there is an urgent and overdue need since the coal industry has suffered a prolonged period of stagnation in technological innovation.

Oil and Natural Gas

Since 1993, private investors have been allowed to import and market liquefied petroleum gas (LPG) and kerosene freely; private investment is also been allowed in lubricants, which are not subject to price controls. Prices for naphtha and some other fuels have been liberalized. In 1997 the government introduced the New Exploration Licensing Policy (NELP) in an effort to promote investment in the exploration and production of domestic oil and gas. In addition, the refining sector has been opened to private and foreign investors in order to reduce imports of refined products and to encourage investment in downstream pipelines. Attractive terms are being offered to investors for the construction of liquefied natural gas (LNG) import facilities.

Electricity

Following the enactment of the Electricity Regulatory Commission Legislation, the Central Electricity Regulatory Commission (CERC) was set up, with the main objective of regulating the Central power generation utilities. State level regulatory bodies have also been set up to set tariffs and promote competition. Private investments in power generation were also allowed. The State SEBs were asked to switch over to separate Generation, Transmission and Distribution corporations. While, India currently does not have a unified national power grid, the country plans to link the SEB grids eventually, and has set up a state company, Powergrid, to oversee the unification.

ENERGY SCENARIO IN INDIA

India's per capita energy and electricity consumptions are less than one tenth of developed countries' per capita consumption. The disparities in urban vs rural; southern, western and northern region vs eastern and north-eastern region; and higher income vs lower income households are very high. Unfortunately, the regions where large fossil and renewable energy sources are available have lower per capita energy consumption. For sustainable and equitable socio-economic development such a situation needs to change.

Given the country's over dependence on coal, large scale import of oil and gas, difficulty in meeting the financial burden of import, environmental consequences of large scale energy production, transformation, transportation and use, it is not wise to strive to achieve the developed country level of energy consumption. To improve the quality of life of Indian citizens, there is no doubt that per capita energy consumption has to increase. Through judicious approach, higher quality of life can be achieved with moderate increase in energy consumption.

The country needs to make timely change of our emphasis on non-renewable energy. Such a change in strategy calls for a paradigm shift in our development approach, i.e. from a unsustainable growth oriented economic development to an environmental friendly equitable development. Since three most serious environment related problems (Global warming, acid rain and ozone layer depletion) owe their origin to energy, it is in our national and global interest that we minimize 'energy want' without sacrificing the 'energy need' for a decent quality of life. A time bound plan is essential to move to 'renewable energy dominant decentralized system' from the existing 'non-renewable energy focused, fossil fuel centric centralized system'.

Energy is essential for every activity of life. There is a strong positive correlation between energy use and the quality of life. At global level, per capita income of a country is directly proportional to the per capita energy consumption (Table 1). Similar trend is also observed in the states of India as well (Table 2 and Figure 1).

Table 1: Socio-economic Indicator for Selected Countries (2008)

Country	Population (Million)	GDP (at 2000 USD ppp)/Capita	Total Primary Energy Supply (kgoe)/Capita	Electricity Consumption (kWh)/Capita
India	1139.97	724.4	540	566
China	1325.64	1963.3	1600	2453
Japan	127.69	40459.5	3880	8072
Germany	82.12	25513.6	4080	7148
US	304.53	38558.7	7500	13647
Sri Lanka	20.16	1198.9	440	409

Table 2: Per Capita GSDP and Electricity Consumption in the States and Country (2006/07)

State	Electricity (kWh)/Capita	GSDP (Rs)/Capita	State	Electricity (kWh)/Capita	GSDP (Rs)/Capita
Andhra Pradesh	802	30485	Manipur	195	18746
Arunachal Pradesh	299	20601	Meghalaya	547	30660
Assam	175	21607	Mizoram	250	24680
Bihar	91	9600	Nagaland	173	26863
Jharkhand	659	23361	Orissa	665	19407
Goa	2098	92010	Punjab	1506	42984
Gujarat	1331	50282	Rajasthan	591	21979
Haryana	1208	47613	Sikkim	533	28307
Himachal Pradesh	872	42391	Tamil Nadu	1080	48468
J & K	759	24625	Tripura	179	20628
Karnataka	806	35818	Uttar Pradesh	341	16756
Kerala	441	37372	Uttaranchal	707	30362
Madhya Pradesh	582	19650	West Bengal	397	29440
Chhatisgarh	935	24921	Delhi	1417	76087
Maharashtra	975	44634	India	672	31605

All of the energy sources that we use, except geothermal and nuclear energies, are derived initially from solar energy. The fossil fuels (coal, oil, and natural gas) are derived from organisms (primarily ocean plankton) that grew over several hundreds of millions of years, storing the solar energy which reached the earth’s surface. Renewable energies (hydro, biomass, and wind) are also directly or indirectly derived from the energy of our sun. Solar energy, though technically not renewable, is normally classified as such because it is effectively inexhaustible on any practical timescale. Nuclear energy is derived from uranium nuclei contained in the earth. This element was formed in heavy stars and was scattered in space when those stars died. Uranium nuclei were present in the dust from which the solar system was formed about 4.5 billion years ago. The earth formed by accretion of such dust and some thermal energy due to this process still remains. However, most of the thermal energy contained in the earth comes from the decay of radio-active nuclei present in the earth and initially produced in stars (Ngo and Natowitz, 2009).

Energy used can be broadly divided into commercial and non-commercial form. Commercial energy, i.e. traded in the market, includes coal, oil, gas, electricity and in some cases biomass. Non-commercial energy includes mostly biomass that is used for cooking, predominantly by the rural communities. Accurate and more recent data on non-commercial energy use in the country is not available. In 2000, India's energy mix was 65% commercial and 35% noncommercial (TEDDY 2010, pp 2). Considering the stage of transformation, energy can also be classified as primary (coal, crude oil, natural gas, water, geothermal, wind, solar heat, biomass, etc.), secondary (steam, chilled water, petrol, diesel, biogas, hydro-electricity, solar electricity, etc.) and tertiary type (electricity). Primary energy sources are those that present prior to any human-induced modification. Higher energy sources are obtained from the transformation of lower sources. Higher form of energy has advantages of cleanliness, ease of operation and control, and obviously expensive. A number of political, economic, social, technological, legal and ecological factors play a critical role in ensuring access to and use of right quantity and quality of energy by the people.

According to the Dy Chairman, Planning Commission (2006), the present energy scenario in India is not satisfactory. The power supply position prevailing in the country is characterised by persistent shortages and unreliability and also high prices for industrial consumer. There is also concern about the position regarding petroleum products. We depend to the extent of 70 percent on imported oil, and this naturally raises issues about energy security. These concerns have been exacerbated by recent movements in international oil prices. Electricity is domestically produced but its supply depends upon availability of coal, exploitation of hydro power sources and the scope for expanding nuclear power, and there are constraints affecting each source.

Principles of energy conservation:

Unit–II Assignment

Resource Availability:

World energy resources are the estimated maximum capacity for energy production given all available resources on Earth. They can be divided by type into fossil fuel, nuclear fuel and renewable resources.

Fossil fuel:

Remaining reserves of fossil fuel are estimated as

Fuel	Proven energy reserves in ZJ (end of 2009)
Coal	19.8
Gas	36.4
Oil	8.9

These are the proven energy reserves; real reserves may be four or more times larger. These numbers are very uncertain. Estimating the remaining fossil fuels on the planet depends on a detailed understanding of Earth's crust. With modern drilling technology, we can drill wells in up to 3 km of water to verify the exact composition of the geology; but half of the ocean is deeper than 3 km, leaving about a third of the planet beyond the reach of detailed analysis.

There is uncertainty in the total amount of reserves, but also in how much of these can be recovered gainfully, for technological, economic and political reasons, such as the accessibility of fossil deposits, the levels of sulfur and other pollutants in the oil and the coal, transportation costs, and societal instability in producing regions. In general the easiest to reach deposits are the first extracted.

Coal:

Coal is the most abundant and burned fossil fuel. This was the fuel that launched the industrial revolution and continued to grow in use; China, which already has many of the world's most polluted cities, was in 2007 building about two coal-fired power plants every week. Coal's large reserves would make it a popular candidate to meet the energy demand of the global community, short of global warming concerns and other pollutants.

Natural gas:

Natural gas is a widely available fossil fuel with estimated 850 000 km^3 in recoverable reserves and at least that much more using enhanced methods to release shale gas. Improvements in technology and wide exploration led to a major increase in recoverable natural gas reserves as shale fracking methods were developed. At present usage rates, natural gas could supply most of the world's energy needs for between 100 and 250 years, depending on increase in consumption over time.

Oil:

It is estimated that there may be 57 ZJ of oil reserves on Earth (although estimates vary from a low of 8 ZJ,[8] consisting of currently proven and recoverable reserves, to a maximum of 110 ZJ[9]) consisting of available, but not necessarily recoverable reserves, and including optimistic estimates for unconventional sources such as oil sands and oil shale. Current consensus among the 18 recognized estimates of supply profiles is that the peak of extraction will occur in 2020 at the rate of 93-million barrels per day (mbd). Current oil consumption is at the rate of 0.18 ZJ per year (31.1 billion barrels) or 85 mbd.

There is growing concern that peak oil production may be reached in the near future, resulting in severe oil price increases.[10] A 2005 French Economics, Industry and Finance Ministry report suggested a worst-case scenario that could occur as early as 2013.[11] There are also theories that peak of the global oil production may occur in as little as 2–3 years. The ASPO predicts peak year to be in 2010. Some other theories present the view that it has already taken place in 2005. World crude oil production (including lease condensates) according to US EIA data decreased from a peak of 73.720 mbd in 2005 to 73.437 in 2006, 72.981 in 2007, and 73.697 in 2008.[12] According to peak oil theory, increasing production will lead to a more rapid collapse of production in the future, while decreasing production will lead to a slower decrease, as the bell-shaped curve will be spread out over more years.

In a stated goal of increasing oil prices to $75/barrel, which had fallen from a high of $147 to a low of $40, OPEC announced decreasing production by 2.2 mbd beginning 1 January 2009.

Nuclear energy:

The International Atomic Energy Agency estimates the remaining uranium resources to be equal to 2500 ZJ. This assumes the use of breeder reactors, which are able to create more fissile material than they consume. IPCC estimated currently proved economically recoverable uranium deposits for once-through fuel cycles reactors to be only 2 ZJ. The ultimately recoverable uranium is estimated to be 17 ZJ for once-through reactors and 1000 ZJ with reprocessing and fast breeder reactors.

Resources and technology do not constrain the capacity of nuclear power to contribute to meeting the energy demand for the 21st century. However, political and environmental concerns about nuclear safety and radioactive waste started to limit the growth of this energy supply at the end of last century, particularly due to a number of nuclear accidents. Concerns about nuclear proliferation (especially with plutonium produced by breeder reactors) mean that the development of nuclear power by countries such as Iran and Syria is being actively discouraged by the international community.

Although at the beginning of the 21st century uranium is the primary nuclear fuel worldwide, others such as thorium and hydrogen had been under investigation since the middle of the 20th century.

Thorium reserves significantly exceed those of uranium, and of course hydrogen is abundant. It is also considered by many to be easier to obtain than uranium. While uranium mines are enclosed underground and thus very dangerous for the miners, thorium is taken from open pits, and is estimated to be roughly three times as abundant as uranium in the Earth's crust.

Since the 1960s, numerous facilities throughout the world have burned Thorium.

Renewable resources:

Renewable resources are available each year, unlike non-renewable resources, which are eventually depleted. A simple comparison is a coal mine and a forest. While the forest could be depleted, if it is managed it represents a continuous supply of energy, vs. the coal mine, which once has been exhausted is gone. Most of earth's available energy resources are renewable resources. Renewable resources account for more than 93 percent of total U.S. energy reserves. Annual renewable resources were multiplied times thirty years for comparison with non-renewable resources. In other words, if all non-renewable resources were uniformly exhausted in 30 years, they would only account for 7 percent of available resources each year, if all available renewable resources were developed.

Solar energy:

Renewable energy sources are even larger than the traditional fossil fuels and in theory can easily supply the world's energy needs. 89 PW[24] of solar power falls on the planet's surface. While it is not possible to capture all, or even most, of this energy, capturing less than 0.02% would be enough to meet the current energy needs. Barriers to further solar generation include the high price of making solar cells and reliance on weather patterns to generate electricity. Also, current solar generation does not produce electricity at night, which is a particular problem in high northern and southern latitude countries; energy demand is highest in winter, while availability of solar energy is lowest. This could be overcome by buying power from countries closer to the equator during winter months, and may also be addressed with technological developments such as the development of inexpensive energy storage. Globally, solar generation is the fastest growing source of energy, seeing an annual average growth of 35% over the past few years. Japan, Europe, China, U.S. and India are the major growing investors in solar energy. Solar power's share of worldwide electricity usage at the end of 2014 was 1%.

Wind power:

The available wind energy estimates range from 300 TW to 870 TW.[24][26] Using the lower estimate, just 5% of the available wind energy would supply the current worldwide energy needs. Most of this wind energy is available over the open ocean. The oceans cover 71% of the planet and wind tends to blow more strongly over open water because there are fewer obstructions.

Wave and tidal power:

At the end of 2005, 0.3 GW of electricity was produced by tidal power. Due to the tidal forces created by the Moon (68%) and the Sun (32%), and the Earth's relative rotation with respect to Moon and Sun, there are fluctuating tides. These tidal fluctuations result in dissipation at an average rate of about 3.7 TW.

Another physical limitation is the energy available in the tidal fluctuations of the oceans, which is about 0.6 EJ (exajoule). Note this is only a tiny fraction of the total rotational energy of the Earth. Without forcing, this energy would be dissipated (at a dissipation rate of 3.7 TW) in about four semi-diurnal tide periods. So, dissipation plays a significant role in the tidal dynamics of the oceans. Therefore, this limits the available tidal energy to around 0.8 TW (20% of the dissipation rate) in order not to disturb the tidal dynamics too much.

Waves are derived from wind, which is in turn derived from solar energy, and at each conversion there is a drop of about two orders of magnitude in available energy. The total power of waves that wash against the earth's shores adds up to 3 TW.

Geothermal:

Estimates of exploitable worldwide geothermal energy resources vary considerably, depending on assumed investments in technology and exploration and guesses about geological formations. According to a 1998 study, this might amount to between 65 and 138 GW of electrical generation capacity 'using enhanced technology'. Other estimates range from 35 to 2000 GW of electrical generation capacity, with a further potential for 140 EJ/year of direct use.

A 2006 report by MIT that took into account the use of Enhanced Geothermal Systems (EGS) concluded that it would be affordable to generate 100 GWe (gigawatts of electricity) or more by 2050, just in the United States, for a maximum investment of 1 billion US dollars in research and development over 15 years.[33] The MIT report calculated the world's total EGS resources to be over 13 YJ, of which over 0.2 YJ would be extractable, with the potential to increase this to over 2 YJ with technology improvements – sufficient to provide all the world's energy needs for several thousand years.[33] The total heat content of the Earth is 13,000,000 YJ.

Biomass:

Production of biomass and biofuels are growing industries as interest in sustainable fuel sources is growing. Utilizing waste products avoids a food vs fuel trade-off, and burning methane gas reduces greenhouse gas emissions, because even though it releases carbon dioxide, carbon dioxide is 23 times less of a greenhouse gas than is methane. Biofuels represent a sustainable partial replacement for fossil fuels, but their net impact on greenhouse gas emissions depends on the agricultural practices used to grow the plants used as feedstock to create the fuels. While it is widely believed that biofuels can be carbon neutral, there is evidence that biofuels produced by current farming methods are substantial net carbon emitters. Geothermal and biomass are the only two renewable energy sources that require careful management to avoid local depletion.

Hydropower:

In 2005, hydroelectric power supplied 16.4% of world electricity, down from 21.0% in 1973, but only 2.2% of the world's energy.

Energy Resources of India:

India has all the possible sources of energy. These include all forms of nonrenewable and renewable energy sources. However, the energy sources are not uniformly distributed. Table 3 indicates the energy sources in major locations of the country.

According to BP Statistical Review of World Energy, India has the third largest proven coal reserves totaling 58600 million Ton, and the country's reserve - to production ratio (R/P) is 105. In 2008/09, the coal and lignite production in the country was 525 million Ton (TEDDY 2010, pp 4-5).

The total oil reserve in the country was estimated to be 786 million Ton in 2004-05. The proven reserve-to-production ratio was 23 in 2004-05 (Planning Commission 2006). In 2009-10 the crude oil production was 33.67 million Ton (TEDDY 2010, pp 86). In 2009-10, 79% of the country's consumption was imported. The crude oil import bill amounting to Rs 3753 billion in 2009/10 put a huge burden on the economy.

Table 3: Key Location of Energy Sources

Energy Source	Key location	Remark
Coal	Jharkhand, Odisha, Chhatisgarh, West Bengal, Andhra Pradesh, Madhya Pradesh, Maharastra	Jharkhand, Odisha and Chhatisgarh constitute 69% of total reserve as on 1 April 2010
Oil	Onshore: Assam, Nagaland, Gujarat, Rajasthan Offshore: Andhra Pradesh, Tamil Nadu, Bombay High	94% of onshore production from the four states in 2009-10.
Gas	Assam, Nagaland, Gujarat, Andhra Pradesh, Tamil Nadu, Rajasthan, Tripura	89% of gas production from Assam, Nagaland, Gujarat, Andhra Pradesh, Tamil Nadu
Hydro-electricity	All the regions of India	76% identified capacity in North-eastern and Northern region
Electricity (hydro and thermal)	All the regions of India	Thermal power plants are concentrated in coal rich states
Uranium and Thorium	Uranium in Jharkhand and Rajasthan Thorium in coastal Odisha, Kerala, Andhra Pradesh and Tamil Nadu	
Wind Energy	Karnataka, Gujarat, Tamil Nadu, Rajasthan, Maharastra, Kerala, Madhya Pradesh, Andhra Pradesh, Odisha, West Bengal	77% of gross potential in Karnataka, Gujarat, Tamil Nadu, Rajasthan and Maharastra
Biomass Energy	All the regions of India	
Solar Energy	All the regions of India	More prominent in Rajasthan desert because of cheap land availability
Geothermal Energy	Chhatisgarh, Jammu and Kashmir, Madhya Pradesh	
Biogas Energy	All the regions of India	

According to the 2008 BP Statistical Energy Survey, in 2007, India had proven natural gas reserves of 1.05 trillion cubic meters, 0.59% of the world total (mbendi, 2010). In 2009-10 the natural gas production was 47.57 BCM (TEDDY 2010, pp 89). The proven reserve-to-production ratio is 22. Based on the discoveries made in recent years, the possibility of having large gas reserve in the sedimentary basins of the country appears to be high.

The estimated deposits of uranium and thorium in the country are respectively 70,000 Ton and

360,000 Ton. Since available uranium is of poor quality (0.06 to 0.07% of the ore) the reactors are designed to take advantage of large thorium deposits. The country has a plan to develop 20000 MW of nuclear capacity by 2020 and 63000 MW by 2032. It is expected that by 2050, 25% of electricity will be coming from nuclear power plants (TEDDY 2010, pp 122).

India has large potential for renewable energy exploitation. However, there is a wide gap between the potential and actual utilisation (Table 4). Technological constraints, high cost of production, weak institution and policy measures are coming in the way of large scale use of renewable energy.

Table 4: Renewable Energy Potential and Actual Achievement

Renewable Energy	Potential	Actual Installed Capacity (as on 31 March 2010)
Wind Power	45,195 MW	11, 807 MW
Bio-power and Bagasse Based Co-generation Power Project	21,881 MW	2,199 MW
Large Hydro Power (>25 MW)	1,48,701 MW	32,128 MW (Developed) 14,225 MW (Under Construction)
Small Hydro Power	15,000 MW	2,735 MW
Solid and Liquid Waste from Urban Areas	2,700 MW	12 MW
Biogas	12 million	4.2 million
Solar Water Heating	140 million m^2	3.53 million m^2
Solar PV System	50 MW/km^2	120 MW
Ocean Thermal Energy Conversion (OTEC)	300,000 MW	-
Wave Energy	40,000 MW	-
Tidal Energy	8,000 MW	-

As on 30th June 2011, the country has a total installed electricity generating capacity of 176,990 MW, besides a grid connected captive capacity of 19,509 MW. Out of it, 115,650 MW is thermal (96,743 of coal fired, 17,706 MW of gas fired and 1200 MW of oil fired) power plants. Balance is contributed by nuclear (4780 MW), hydro-electric (38,106 MW) and renewable energy sources (18,455 MW) including small hydro, biomass gasifiers, urban and industrial waste power and solar. Based on the sources of primary energy for electricity production, the installed capacity mix of coal, hydro, gas, diesel, nuclear and renewable energy are 55%, 21.5%, 10%, 0.7%, 2.7% and 10% respectively (CEA, 2011).

Out of total generation of 766 Billion Units (BU) in 2009¬10, the generation mix of thermal, hydro and nuclear sources were respectively 640.5 BU (84%), 106.6 BU (14%) and 18.6 BU (2%). The supply constrained demand of electricity had an energy deficit of 9.9% and peak power deficit of 12.6% in 2009/10 in the country. The state¬wise electric energy and electric power deficit during 2008/09 are shown in Figure 2 and Table 5 (TEDDY 2010, pp 167¬170).

Energy savings and Current energy consumption in India:

Energy efficiency improvements reduce the amount of energy use required to provide a service. Energy savings are at the heart of the multiple benefits of energy efficiency and link to many other economic, social and environmental benefits.

Increased greenhouse gas emissions as a result of India's increased energy consumption and the country's future dependence on fossil fuels to serve its energy security have raised serious environmental concerns. As an emerging economy, India has a huge opportunity to meet its development goals in minimal energy consumption. Energy efficiency, termed as 'the first fuel' by the International Energy Agency (IEA), will play a pivotal role in determining an optimal energy portfolio for India.

The deployment of clean energy systems is gaining momentum through policy interventions in India and across the globe. Although, one of the most inexpensive achievable option available is adopting an energy efficient lifestyle. Energy efficiency is increasingly becoming a key pillar of energy transformation policies in the world. Implementing robust energy efficiency interventions lead to curbed air pollution, decarbonisation, improved energy access, better resource use and enhanced energy security. The transition to clean energy will be faster and cheaper if energy efficiency measures are undertaken.

As a part of the Paris Agreement, India has committed to reducing its energy intensity (units of energy use per unit of GDP) by 33-35 percent by 2030 compared to the 2005 levels. The implementation of various energy efficiency schemes by the Bureau of Energy Efficiency (BEE) such as the National Mission for Enhanced Energy Efficiency (NMEEE), Demand Side Management (DSM), Energy Conservation Building Code (ECBE), etc. have yielded positive results. As per recent data released by the power ministry, the country has already reduced the energy intensity of its economy by 20 percent compared to 2005 levels. This has resulted in total energy savings of 23.73 MTOE (million tonnes of oil equivalent) in 2018-19, resulting in savings worth INR 891.22 billion. There is a still a vast untapped opportunity to expand energy efficiency measures in the residential, micro, small and medium enterprises and the transport sectors.

Poorly-designed buildings lead to higher energy consumption per unit of the built area. Inefficient buildings make the inhabitants uncomfortable, increasing their need for more appliances to improve well-being. Efficient use of material and resources in construction will result in low energy loads in buildings. The state governments need to prioritise the uptake of Energy Conservation Building Codes (ECBC) for both commercial and residential buildings and make it mandatory in new building construction. The BEE recently launched a new programme for conducting feasibility tests on 100 existing buildings to develop a framework to transform them into Nearly Zero Energy Buildings (NZEB). The objective of this initiative is to develop a framework for conventional buildings to achieve low energy use per unit area. It is crucial for India to push for the expansion of the NZEB programme to all segments of the construction sector. A report by the International Finance Corporation (IFC) has stated that in emerging markets, green buildings will offer a USD 24.7 trillion investment opportunity. The government of Maharashtra has partnered with the IFC to promote green housing. There is a need to develop ties with various multilateral organisations to fund such green housing initiatives.

The high ambitions of citizens to live and work in comfortable airconditioned spaces with appliances providing ease of living will lead to a multifold increase in energy consumption. An approach to change the course of energy use behaviour through energy efficiency programmes is needed to curb future energy demand. There is a need to run multiple large-scale awareness campaigns to inform consumers about the benefits of energy efficiency. Appliances like refrigerators, air conditioners, geysers, microwaves, coolers and heaters, television, lights and fans contribute to residential electricity consumption. Adoption of energy efficient models of these gadgets can substantially cut future electricity consumption. The standard and labelling (S&L) programme started by BEE sets mandatory standards to make these appliances energy efficient and promotes them through labels. Currently there are ten appliances which need to have mandatory standards and labels whereas 16 under the voluntary category. The energy performance for many of these appliances has been made stringent recently which shall help in the long run. To promote commercially available efficient technologies, the BEE regularly tightens the standards and labels of these appliances. India needs to strive to compare these standards with international standards for further improvement.

There is also a need for behavioural interventions for nudge consumers to buy 5-star appliances. A recent example of such intitiative by the BEE and central government is the newly set energy efficiency standards for room air conditioners where the default temperature is to be set at 24°C which leads to electricity conservation. The BEE also launched super-efficient air conditioners and hopes to sell 50,000 units (expected to save 27 million units of electricity and mitigate 22,140 tonnes of CO2 annually) in the first phase of the project raising it to 250,000 by second phase by investing INR 200 crores. Such bulk procurement programmes can help in changing markets to energy efficient appliances and reducing the prices due to economies of scale. The credibility of the S&L programme can be increased by bringing transparency in the process of fixing standards and ensuring compliance. Testing random samples of appliances from the market will increase the trust between sellers and consumers. The BEE has also recently released new star rating standards for fluorescent lamps and ceiling fans. The BEE along with consumer and civil society groups should scale up efforts for promotion of energy efficient appliances.

There is inadequate data on residential energy end-use which results in assumptions to model policies. In this context the BEE has launched the National Energy End-use Monitoring (NEEM) dashboard which will help in monitoring end-use energy consumption data and establish consumer behaviour patterns. This will help in projecting future electricity needs and demand side energy management strategies. It can also help in targeted sale of energy efficient appliances and developing outreach and awareness campaigns. There is an urgent need to scale up this intervention to different household types, geographies and climate profiles.

Also, India's power sector is slated for a revamp with multiple policy level changes through the amendment of the Electricity Act. One of the major initiatives as a solution to issues like low billing efficiencies leading to revenue losses, heavy transmission and distribution losses, monitoring of electricity consumption, etc. is installation of smart meters. The government of India is targeting installation of 250 million smart meters over the next few years. Smart meters will enable access to real-time data of electricity use, both for the distribution companies and the consumers, which will aid in tracking the quality of power supply and help in predictive maintenance and future infrastructure planning. Monitoring of data at household level will identify consumption segments leading to peak demand helping discoms to propose load flattening interventions, tariff rationalisation and avoiding additional power generation. This will also help in preparing demand side management strategies which can be targeted to create awareness among individual consumers to promote energy conservation schemes. Hence, the installation of smart meters at a fast pace can help India in facilitating energy efficiency interventions at a large scale.

Energy efficiency interventions are one of the most cost-effective means of achieving a low carbon transition. Early adoption of energy efficient strategies will have a bearing on future energy use and hence impact of climate change and conservation of various energy resources can provide affordable, reliable and sustainable energy access solutions to underserved populations. Embracing an energy efficient lifestyle will provide a positive impetus towards transformation of India's energy system for the better.

Current energy consumption in India:

The energy policy of India is largely defined by the country's expanding energy deficit and increased focus on developing alternative sources of energy, particularly nuclear, solar and wind energy. India attained 63% overall energy self-sufficiency in 2017.

The primary energy consumption in India grew by 2.3% in 2019 and is the third biggest after China and USA with 5.8% global share. The total primary energy consumption from

coal (452.2 Mtoe; 55.88%),

crude oil (239.1 Mtoe; 29.55%),

natural gas (49.9 Mtoe; 6.17%),

nuclear energy (8.8 Mtoe; 1.09%),

hydro electricity (31.6 Mtoe; 3.91%) and

renewable power (27.5 Mtoe; 3.40%) is 809.2 Mtoe (excluding traditional biomass use) in the calendar year 2018.

In 2018, India's net imports are nearly 205.3 million tons of crude oil and its products, 26.3 Mtoe of LNG and 141.7 Mtoe coal totaling to 373.3 Mtoe of primary energy which is equal to 46.13% of total primary energy consumption. India is largely dependent on fossil fuel imports to meet its energy demands – by 2030, India's dependence on energy imports is expected to exceed 53% of the country's total energy consumption. About 80% of India's electricity generation is from fossil fuels. India is surplus in electricity generation and also marginal exporter of electricity in 2017. Since the end of calendar year 2015, huge power generation capacity has been idling for want of electricity demand. India ranks second after China in renewables production with 208.7 Mtoe in 2016.

In 2017-18, the per-capita energy consumption is 23.355 Giga Joules (0.558 Mtoe) excluding traditional biomass use and the energy intensity of the Indian economy is 0.2332 Mega Joules per INR (56 kcal/INR). Net energy import dependency was 40% in 2018-19. Due to rapid economic expansion, India has one of the world's fastest growing energy markets and is expected to be the second-largest contributor to the increase in global energy demand by 2035, accounting for 18% of the rise in global energy consumption.

Given India's growing energy demands and limited domestic oil and gas reserves, the country has ambitious plans to expand its renewable and most worked out nuclear power programme. India has the world's fourth largest wind power market and also plans to add about 100,000 MW of solar power capacity by 2022. India also envisages to increase the contribution of nuclear power to overall electricity generation capacity from 4.2% to 9% within 25 years. The country has five nuclear reactors under construction (third highest in the world) and plans to construct 18 additional nuclear reactors (second highest in the world) by 2025. During the year 2018, the total investment in energy sector by India was 4.1% (US$ 75 billion) of US$ 1.85 trillion global investment.

Indian solar power PV tariff has fallen to ₹2.44 (3.4¢ US) per kWh in May 2017 which is lower than any other type of power generation in India. In the year 2020, the levelized tariff in US dollars for solar PV electricity has fallen to 1.35 cents/kWh. Also the international tariff of solar thermal storage power plants has fallen to US$0.063/kWh, which is cheaper than fossil fuel plants. The cheaper hybrid solar power (mix of solar PV and solar thermal storage power) need not depend on costly and polluting coal/gas fired power generation for ensuring stable grid operation. Solar electricity price is going to become the benchmark price for deciding the other fuel prices (petroleum products, natural gas/biogas/LNG, CNG, LPG, coal, lignite, biomass, etc.) based on their ultimate use and advantages.

Roles and responsibilities of energy managers in industries:

Roles:

An Energy Manager monitors and manages the energy efficiency of a facility or organization. They implement conservation measures, monitor energy consumption, assess business decisions for sustainability and seek out opportunities for increasing energy efficiency.

The role of an Energy Manager (EM) involves facilitating energy conservation by identifying and implementing various options for saving energy, leading awareness programs, and monitoring energy consumption.

Responsibilities:

1. Prepare an annual activity plan and present to management concerning financially attractive investments to reduce energy costs.
2. Establish an energy conservation cell within the firm with management's consent about the mandate and task of the cell.
3. Initiate activities to improve monitoring and process control to reduce energy costs.
4. Analyze equipment performance with respect to energy efficiency.
5. Ensure proper functioning and calibration of instrumentation required to assess level of energy consumption directly or indirectly.
6. Prepare information material and conduct internal workshops about the topic for other staff.
7. Improve disaggregating of energy consumption data down to shop level or profit center of a firm.
8. Establish a methodology how to accurately calculate the specific energy consumption of various products/services or activity of the firm.
9. Develop and manage training programme for energy efficiency at operating levels.
10. Co-ordinate nomination of management personnel to external programs.
11. Create knowledge bank on sectoral, national and international development on energy efficiency technology and management system and information denomination.
12. Develop integrated system of energy efficiency and environmental upgradation, wide internal & external networking.
13. Co-ordinate implementation of energy audit/efficiency improvement projects through external agencies.
14. Establish and/or participate in information exchange with other energy managers of the same sector through association.