LECTURE – 3

Lecture-3 Renewable Energy- Potentials and Achievements

Importance- Conventional energy Sources – Potential and Achievements in India

Energy is one of the major building blocks of modern society. Energy is needed to create goods from natural resources. Economic development and improved standards of energy are complex processes that share a common denominator: the availability of an adequate and reliable supply of energy. Political events, beginning with an oil embargo in 1973 and continuing through the Iranian revolution of 1979 and the Persian Gulf War of 1991, made many people aware of how crucial energy is to the everyday functioning of our society. Long gasoline lines and cold winters with natural gas shortages in the 1970s are still unhappy memories for some people. The energy crisis of the 1970s was almost forgotten by the 1980s. However, that decade brought an increased awareness of over environment. Concerns about global warming, acid rain and radioactive waste are still very much with us today, and each of these topics is related to our use of energy.

Energy pervades all sectors of society; economics, labour, environment, international relations in addition to our own personal livings i.e., housing, food, transportation, recreation and more. The use of energy resources has relieved us from many drudgeries and made our efforts more productive. Human beings once had to depend on their own muscles to provide the energy necessary to do work. Today our muscles supply less than 1% of the work done in the industrialized world.

Energy might best be described in terms of what it can do. We cannot see energy, only its effects; we cannot make it, only use it; and we cannot destroy it, only waste it through inefficient use. Unlike food and housing, energy is not valued in it but for what can be done with it.

Energy is a basic concept in all the science and engineering discipline. A very important principle is that energy is a conserved quantity, i.e., the total amount of energy in the universe is constant. Energy is not created or destroyed but just converted or redistributed from one form '

to another, such as from wind energy into electrical energy or from chemical energy into heat etc.

Classification of energy on the basis of source

On the basis of source, the energy can be classified as direct and indirect energy.

1. Direct source of energy

The direct sources of energy are those, which release the energy directly-like human labor, bullocks, stationary and mobile mechanical or electric power units, such as diesel engines, electric motor, power tiller and tractors. The direct energy may be further classified as renewable and non-renewable sources of energy depending upon their replenishment.

1.1. Renewable direct sources of energy

In this category, the energy sources, which are direct in nature but can be subsequently replenished, are grouped. The energies, which may fall in this group, are human beings, animals, solar and wind energy, fuel wood, agricultural wastes, etc.

1.2. Non-Renewable direct sources of energy

In this category, direct energy sources that are not renewable (at least in near future say next 100 years) are classified. Coal and fossil fuels exemplify non-renewable direct sources of energy.

2. Indirect sources of energy

The indirect sources of energy are those, which do not release energy directly but release it by conversion process. Some energy is invested in producing indirect sources of energy. Seeds, manures (farm yard and poultry), chemicals, fertilizers and machinery can be classified under indirect sources of energy. Again, on the basis of their replenishment, these can be further classified into renewable and non-renewable indirect source of energy.

2.1. Renewable indirect source of energy

Seed and manure can be termed as renewable indirect source of energy as they can be replenished in due course of time.

2.2. Non-renewable indirect source of energy

The energy sources, which are not replenished, come under non-renewable indirect sources of energy. Chemicals, fertilizers and machinery manufacturing are the non-renewable indirect sources of energy.

Classification of energy on the basis of comparative economic value

On the basis of comparative economic value the energy may be classified as commercial and non-commercial.

1. Non-commercial energy

Each and every energy source has some economic value. Some energy sources are available comparatively at low cost whereas others are capital intensive. The energy sources, which are available cheaply, are called non-commercial sources of energy whereas the ones which are capital intensive are called commercial energy sources.

Human labor and bullocks exemplify the category of non-commercial source of energy. One may argue that the unit energy available from animate sources is costlier than the mechanical energy. Therefore, animal sources of energy should be classified under the non-commercial. However, one should also bear in mind that human labour and animals are readily available and can be used as a sources of power directly, whereas in case of mechanical sources of energy, the machines (tractors, stationary engines, electric motors, etc. are very costly in terms of their purchase price and also often require a skilled operator.

The commonly available and less expensive materials like fuel wood, twigs, leaves agro-wastes and animal dung, etc. are also classified as non-commercial sources of energy.

2. Commercial energy

The energy sources like petroleum products (diesel, petrol and kerosene oil) and electricity, which are capital intensive exemplify / commercial sources of energy. Considering the fact that most of the commercial sources are also non-renewable and to some extent are imported in India, efforts are made to conserve such sources of energy.

Fundamentals Of Renewable/Non Renewable Energy Sources

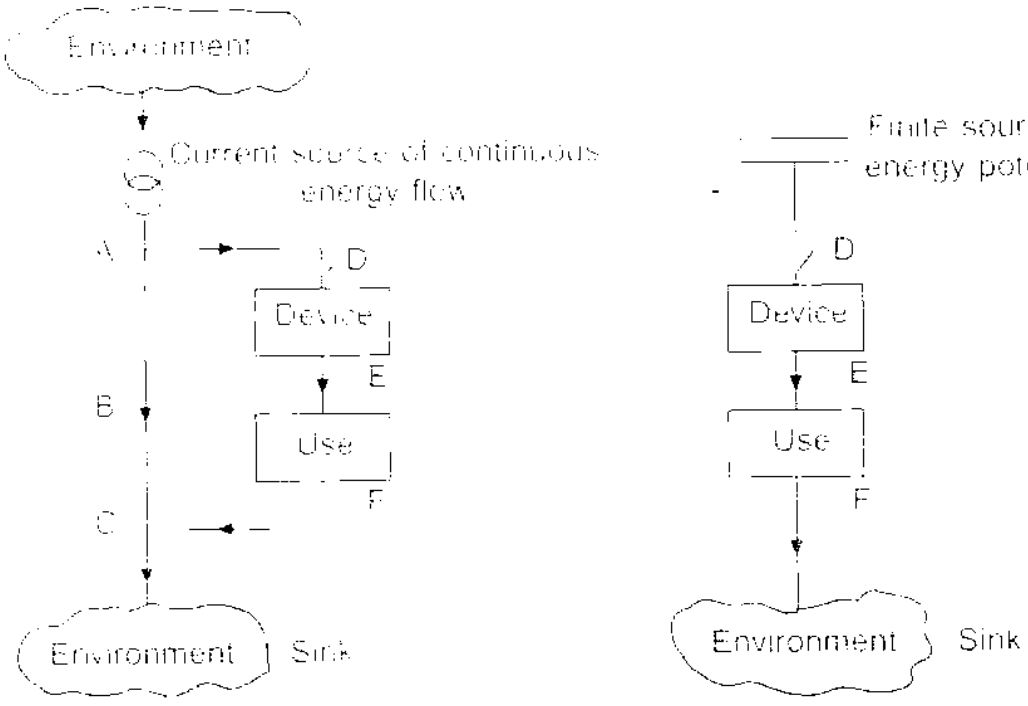
Definitions

For all practical purposes, energy, supplies can be divided into two classes:

"Renewable energy is the energy obtained from regenerative or virtually inexhaustible sources of energy occurring in the natural environment like solar energy, wind energy etc. That type of energy is passing through the environment irrespective of there being a man made device to intercept and harness the power. This is also referred as **non-conventional sources of energy."**

"Nonrenewable energy is the energy obtained from static stores of energy which remain bound unless released by human interaction. Examples are fossil fuels of coal, oil and natural gas and nuclear fuels. That type of energy is initially in an isolated energy potential and external action is required to initiate the supply of energy for practical purposes. This type of energy is also sometimes called finite energy or **conventional sources of energy. "**

These two definitions are portrayed in Figure 1. Table .3 provides a comparison between renewable and nonrenewable energy system.



Renewable energy **Finite energy**

Figure. 1. Contrast between renewable and finite energy supplies

Energy Sources

1. There are six ultimate sources of useful energy:
2. The Sun;
3. The motion and gravitational potential of the sun, moon and earth;
4. Geothermal energy from cooling, chemical reactions and the radioactive decay inside the earth;
5. Nuclear reactions on the earth;
6. Chemical reactions from mineral sources; and
7. Fossil fuel (Petroleum product and gases).

Table .1 Comparision of renewable and nonrenewable energy systems

Features of comparision	***Renewable energy supplies***	***Nonrenewable energy supplies***
Examples	Wind, solar, biomass, tidal etc.	Coal, oil, gas etc.
Source	Natural local environment	Concentrated stock
Normal state	A current of energy	Static store of energy
Life time of supply	Infinite	Finite
Cost at source	Free	Increasingly expensive
Location for use	Site and society specific	General and international use
Scale	Small scale, economic, large scale may present difficulties	Increased scale often improves supply costs, large scale frequently favored
Skills	Interdisciplinary and varied wide range of skills	Strong links with electrical and mechanical engineering. Narrow range of skill
Context	Rural, decentralized industry	Urban, centralized industry
Dependence	Self-sufficient system encouraged	Systems dependent on outside inputs
Pollution and environmental damage	Usually little environmental harm, especially at moderate scale. Hazards Wind, solar, biomass, tidal etc. from excessive wood burning, soil erosion from excessive biofuel use, large hydro reservoirs disruptive	Environmental pollution common, and especially of air and water Deforestation and ecological sterilization from excessive air pollution
Safety	Local hazards possible in operation, usually safe when out of action	May be shielded and enclosed to lessen great potential danger

Renewable energy is derived from sources 1. 2 and 3. Finite energy namely non renewable (conventional energy) is derived from sources 4, 5 and 6.

Renewable Energy Sources

The continuing depletion of fossil fuels and the environmental hazards posed by the needs of future development are gradually shifting the path of development towards sustainability, better sociability and environmental responsibility which in turn emphasizes the need for renewable energy sources. The area of renewable energy sources is expanding rapidly and numerous innovations as well as applications are taking place. The decentralized renewable energy systems concept has been recognized as an answer to meeting the energy demands both in the household and in the agro-industrial sector. The exhaustion of natural resources and the accelerated demand of conventional energy have forced planners and policy makers to look for alternate sources.

Presently, even though commercial energy sources like coal, oil, natural gas are being utilized to a large extent, renewable sources of energy are slowly gaining importance. Renewable energy plays a basic ingredient for sustainable development. Such sources can supply the energy we need for indefinite periods of time polluting far less than fossil fuels. The advantages of renewables are well known, as far as they enhance diversity in energy supply markets; secure long-term sustainable energy supplies; reduce local and global atmospheric emissions; create new employment opportunities offering possibilities for local manufacturing.

Energy Scenario In India

Energy-use Statistics

Currently, India is the sixth largest energy consumer in the world and the country's energy consumption is expected to increase in the near future. In the past, India has derived most of its energy from coal, but recently the country has been making efforts to extract energy from other sources. However, fossil fuels still remain the largest energy source. About 76% of India's electricity is produced in power plants using coal or petroleum products (Buran et al., 2003).

Of the remainder, 22% is hydroelectric and 2% is nuclear. According to data from India's Ministry of Statistics and Programme Implementation, the nation's total energy

consumption has increased approximately fourfold over the last three decades. In 1999, India had an electricity consumption total of approximately 4.24×10^{11} KWh (Anon, 2001).

India is the world's third largest coal producer, ranking behind only the United States and China. Current domestic production of coal meets approximately 95% of domestic demand. Coal consumption is expected to increase by 28% by 2010 and is expected to remain the primary source of fuel despite increased reliance on natural gas (Lynch, 2001). Oil provides roughly 30% of India's energy, but domestic production of oil provides for only a third of India's oil demand. By 2010, roughly 75% of India's oil and gas need will be met by imports (Lynch, 2001). The government predicts that, with present consumption and production trends, India will deplete its oil reserves by 2012. The Indian government is now encouraging exploration for oil to reduce its dependence on imports. However, many researchers believe that India's easy-access reserves have already been tapped.

There are numerous projections for India's energy consumption in the coming years and all agree that the increase will not simply be linear. One estimate projects an 8-10% annual increase in energy demand over the next 15 years if the economy continues to grow at the expected rate of 7-8% per year (Buran et. al., 2003).

Pollution Statistics

India emits the fifth most carbon of any country in the world: at 253 million metric tons, only the United States, China, Russia and Japan surpassed its 1998 level of carbon emissions. The carbon emissions have grown ninefold over the past 40 years and are forecasted to grow 3.2% per year until 2020, and are faster than both China and the United States.

The Indian Government estimates the cost of environmental degradation in recent years to be 4.5% of GDP.

Low energy-efficiency of coal-burning power plant is a contributing factor. India's coal plants are old and are not equipped with the most modern pollution controls. With the shortage of generating capacity and scarcity of public funds, old coal-fired plants will likely remain in operation for sometime. Power plant modernization, improvements in transmission to cut distribution losses and legislation to encourage end-user energy conservation are all part of the Government's current energy efficiency efforts.

Emerging industrial centers and the lack of pollution-control mechanisms have resulted in a severe drop in air quality in India. Of the 3 million premature deaths in the world that occur

annually due to air pollution, more than 5,00,000 occur in India (Anon, 2000). According to the World Health Organization, the city of New Delhi is one of the ten most polluted cities in the world (Michaels, 2001).

Nuclear Energy

India has 14 nuclear reactors operating with 2720 MWe combined generating capacity. Four 220 MWe reactors were commissioned between late 1999 and December 2000. The Nuclear Power Corporation of India Limited (NPCIL) wants to boost capacity to 20,000 MWe by 2020 (7 -10%> of total electricity generating capacity). The outlook is improving for India's nuclear-power industry, as plants have been running at an average capacity factor of 80% and reactor outages have been shortened. Quality of fuel supplies has risen and delivery times have improved. In 1999, NPCIL declared its first dividend, but nuclear industry is still heavily reliant on Government funding. Government spending for research and development for the current five7year plan is $193.5 million which is five times the previous level. By mid-2001, two more reactors were scheduled to enter critical development stages. Construction is progressing on two 500 MWe units: the first uses Indian-developed design and technology. Construction is also scheduled for six additional reactors.

Alternative Energy Projections

By 2010, India wants 10% of all additional electric capacity to come from renewable energy sources. The Indian Renewable Energy Development Agency (commonly known as IREDA), which is a part of the Ministry of Non-Conventional Energy Sources, oversees the development of these energy sources.

Renewable Energy Potential In India

Renewable Energy Programme

The relevance of the increasing use of renewable energy sources in the transition to a sustainable energy base was recognised in India even in the early 1970s. Since the early 1980s, a significant thrust has been given to the development, trial and induction of a variety of renewable energy technologies for use in different sectors. To begin with, the endeavours were steered and overseen by the Commission for Additional Sources of Energy (CASE) set up in 1981. In 1982, a separate Department of Non-Conventional Energy Sources (DNES) was

created in the Ministry of Energy and was entrusted with the charge of promoting non-conventional energy sources. A decade later, this was upgraded and thus MNES (Ministry of Non-Conventional Energy Sources) started funding as a separate Ministry from 1992 to develop all areas of renewable energy.

As per its mandate, the MNES has been implementing a broad-based programme covering the whole spectrum of renewable energy technologies. The aim of the programme is to (a) increase me share of renewables in the overall installed capacity power generation (b) meet the energy needs of rural and remote areas for a variety of applications (c) minimize the drudgery and health hazards faced by rural women in following the age-old practice of cooking with fuel-wood collected from long distances and in traditional chulhas which emit a lot of smoke and (d) extract energy from urban and industrial waste besides chemical, ocean and geo-thermal sources. The underlying idea of the programme is not to substitute but to supplement the conventional energy generation in meeting the basic energy needs of the community at large.

Current Status

The national programmes in different areas of renewable energy sector have resulted not only in generation of public awareness about the advantages of renewable energy but also in a visible increase in the deployment of renewable energy systems and devices for varied applications. Consequently, the contribution of renewable energy to total installed capacity of power generation has been progressively rising. As on October, 2003, the contribution of renewables has reached 4132 MW, representing about 4% of total grid capacity, as compared to 2414 MW on October 1999. Almost all the areas namely solar, wind, biomass, small hydro and urban as well as industrial waste have contributed to the satisfactory achievement of renewable energy sources in the country. With a wind power capacity of 2000 MW, India now ranks fifth in the world. Small hydropower generation, which is particularly suitable for remote and hilly regions, is being expanded. India is the largest producer of cane sugar and the world's largest bagasse based co-generation programme is being implemented in the sugar mills. There is also considerable scope for extracting energy from urban and industrial wastes.

The programmes to meet the rural energy needs are the National Project on Biogas Development (NPBD) and the National Programme on Improved Chulhas (NPIC). The NPBD aims at harnesing the fuel value of the cattle dung, human waste and non-woody organic wastes

without losing their manurial value and minimising the drudgery of rural woman in walking long distances to collect fuel wood. The objective of NPIC is to improve efficiency of biomass fuels without indoor air pollution.

Rapid urbanisation and industrialisation have led to generation of huge quantities of wastes, which are rich sources of energy. Under the National Programme on Energy Recovery from urban, municipal and industrial wastes, promotion and development of projects leased on appropriate conversion technologies such as biomethanation, gasification, palletisation and land fills is being undertaken. This programme aims at harenessing the estimated power generation potential of about 1000 MW from urban and municipal wastes and about 700 MW from industrial wastes. Projects with an aggregate capacity of 26 MWe have been completed. The achievements of various renewable energy sources in India during the last four years has been shown in Table2.

Table.2 Renewable energy achievements in India during the last four years

SI. No	*Programmes*	*As on 12.10.1999*	*As on 12.10.2003*
A.	**Grid Connected Systems** (installed capacity in MW)		
	Wind power	1022.00	2002.00
	Small Hydro	1218.00	1530.00
	power Biomass/Cogeneration power	171.00	571.00
	Urban and industrial waste power	2.00	26.00
	Solar photovoltaic power	1.00	3.00
	Total	2414.00	4132.00
B.	**Decentralized systems**		
	Biogas plants (Nos. in lakh)	28.80	35.50
	biogas plants (Nos.)	2, 673.00	3. 902.00
	Improved chulha (Nos. in lakh)	250.00	350.00
	Solar home lighting systems(No)	64,000.00	2,60,00000
	Solar street lighting sys. (Nos.)	32,920.00	43,470.00
	Solar lanterns (Nos. in lakh)	2.22	4.42
	SPV pumps (Nos.) (solar pv)	2, 160.00	6, 400.00
	Solar water heating system (lake sq. meter collector area)	5.70	7.00

Source: http:// mnes.nic.in [Ministry of Non-Conventional energy sources. New Delhi, India]

Besides sun, wind, biomass, small hydro and urban and industrial wastes, there are other sources of renewable energy, which are mostly in the stage of R & D. These include fuel cell, hydrogen energy, geothermal and ocean energy. Significant progress has been recorded during the year in areas of fuel cell technology, hydrogen energy, battery-powered vehicles and tapping geo-thermal energy under the Ministry's programme on new technologies. Installation of a demonstration geothermal power plant of 300 kW capacity at tattapani in Chhatisgarh state is being taken up through National hydro Power Corporation, India. A detailed project report for a 3 MW tidal powerplant in Sunderbans area of West Bengal has been prepared through West Bengal Renewable Energy Development Agency.

Importance of Renewable Energy Resources and Technologies for Sustainable Development

The exploitation of renewable energy resources and technologies is a key component of sustainable development (Anon, 1995). There are three significant reasons for it as follows:

They have much less environmental impact compared to other sources of energy since there are no any energy sources with zero environmental impact. There are a variety of choices available in practice that shift to renewables for providing a far cleaner energy system than would be feasible by tightening controls on conventional energy.

Renewable energy sources cannot be depleted unlike fossil fuel and uranium resources. If used wisely in appropriate and efficient applications, they can provide a reliable and sustainable supply energy almost indefinitely. In contrast, fossil fuel and nuclear energy sources are finite and can be diminished by extraction and consumption,

They favour power system decentralization and locally applicable solutions more or less: independent of the national network, thus enhancing the flexibility of the system and the economic power supply to small isolated settlements. That is why, many different renewable energy technologies are potentially available for use in urban areas.

Essential Factors for Sustainable Developments

The main concept of sustainability, which often inspires local and national authorities to incorporate environmental considerations in setting energy programme, though being given many different meanings in different contexts, embodies a long-term perspectives. Besides, the future energy system will be largely shaped by broad and powerful trends that have their roots in basic human needs. In conjunction with this, the increasing world population requires the

definition and successful implementation of sustainable development. There are various essential parameters that can help in achieving a successful sustainable development in a society. Such parameters can be described as follows:

Public awareness: This is the initial step and very crucial in making the sustainable energy programme successful. This should be carried out through the media and by public and/or professional organization.

Information: Necessary informational input on energy utilization, environmental impacts, renewable energy resources etc. should be provided to public through public and government channels

Environmental education and training: This can be implemented as a completing part of the information. Any approach which does not have an integral education and training is likely to fail. That is why, this can be considered as the significant prerequisite for a ' sustainable energy program. For this reason, a wide scope of specialized agencies and training facilities should be made available to the public.

Innovative energy strategies: These should be provided for an effective sustainable energy program and therefore require the efficient dissemination of information, based on new methods and consisting of public relations, training and counseling

Promoting renewable energy resources: In order to achieve environmentally benign sustainable energy programs, renewable energy sources should be promoted in every stage. This will create a strong basis for the short and long term policies.

Financing: This is a very important tool that can be used for reaching the main goal and will accelerate the implementation of renewable energy systems and technologies for sustainable energy development of the country. Some countries, e.g., Germany, apply the support a different way and simply exempt the people who use such systems and technologies from some portion of their taxes.

Monitoring and evaluation tools: In order to see how successfully, the program has been implemented, it is of great importance to monitor each step and evaluate the data and findings obtained. In this regard, appropriate monitoring and evaluation tools should be used.