RENEWABLE ENERGY

[TH-4]

6TH SEM ELECTRICAL ENGG.

Under SCTE&VT, Odisha

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Module-1

Energy Sources:- Energy storage can be defined as means of storing energy in a readily recoverable form when the supply exceeds the demand for use at other times. Storage of primary fuels (e.g. coal, oil and gas) is also a form of energy storage, but the term 'energy storage' generally applies to secondary energy rather than primary energy.

Classification:-
Energy resources can be classified on the basis of following criteria:

1. Based on Usability of Energy

a) Primary resources- Examples of primary energy resources are coal, crude oil, sunlight, wind, running rivers, vegetation and radioactive material like uranium etc.
These resources are generally available in raw forms and are therefore, known as raw energy resources. Generally, this form of energy cannot be used as such. These are located, explored, extracted, processed and are converted to a form as required by the consumer.

$$\text{Energy Yield Ratio} = \frac{\text{Energy received from raw energy source}}{\text{Energy spent to obtain raw energy source}}$$

(b) Secondary Resources The energy resources supplied directly to consumer for utilization after one or more steps of transformation are known as secondary or usable energy, e.g. electrical energy, thermal energy (in the form of steam or hot water), refined fuels or synthetic fuels such as hydrogen fuels, etc.

2. Based on Traditional Use

(a) Conventional Energy resources, which are being traditionally used, for many decades and were in common use around oil crisis of 1973, are called conventional energy resources, e.g. fossil fuels, nuclear and hydro resources.
(b) Non-conventional Energy resources, which are considered for large-scale use after the oil crisis of 1973, are called non-conventional energy sources, e.g. solar,wind, biomass, etc.

3. Based on Long-Term Availability

(a) Non-renewable Resources, which are finite and do not get replenished after their consumption, are called non-renewable e.g. fossil fuels, uranium, etc. They are likely to deplete with time.
(b) Renewable Renewable energy is energy obtained from sources that are essentially inexhaustible. Examples of renewable resources include wind power, solar power, geothermal energy, tidal power and hydroelectric power. The most important feature of renewable energy is that it can be harnessed without the release of harmful pollutants.

4. Based on Commercial Application

(a) Commercial Energy Resource-The energy sources that are available in the market for a definite price are known as commercial energy. Most important forms of commercial energy are electricity, coal and refined petroleum products. Applications of solar energy, wind energy, hydro energy for electricity and lifting water from the ground require technology are termed as commercial energy sources.
(b) Non-commercial Energy The energy sources that are not available in the commercial market for a price are classified as non-commercial energy. All energy sources which are available in nature like wind, sun, hydro etc. are non-commercial energy sources. Non-commercial energy sources include fuels such as firewood, cattle dung and agricultural wastes, which are traditionally gathered, and not bought at a price, used especially in rural households.

5. Based on origin

(a) Fossil fuels energy
(b) Nuclear energy

(c) Hydro energy
(d) Solar energy
(e) Wind energy
(f) Biomass energy
(g) Geothermal energy
(h) Tidal energy
(i) Ocean thermal energy
(j) Ocean wave energy

Consumption trend of Primary Energy resources

The global average consumption trend of various primary energy resources of the world is indicated in Fig. 1.

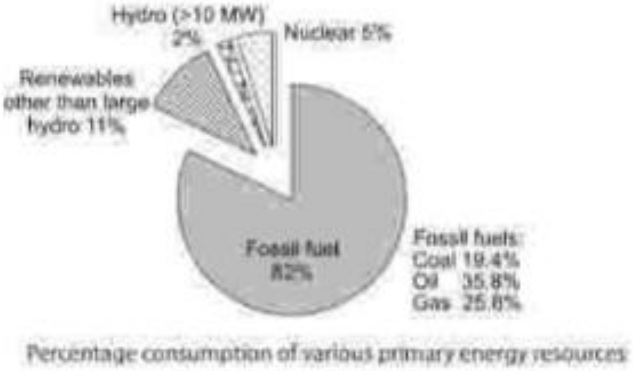

Fig .1

Importance of non-conventional energy sources

The concern for environment due to ever-increasing use of fossil fuels and rapid depletion of these resources has led to development of alternative sources of energy, which are renewable and environment friendly. Following points may be mentioned in this connection:

1. Conventional sources (except hydro) are non-renewable and finite assets. With present rate of consumption their availability is rapidly declining.
2. The demand of energy is increasing exponentially due to rapid industrialization and population growth, the conventional sources of energy alone will not be sufficient in the long run, to meet the growing demand.
3. Conventional sources (fossil fuels, nuclear) also cause pollution leading to degradation of the environment. Ultimately, their use has to be restricted within acceptable limits.
4. Large hydro resources affect wild life, cause deforestation and pose various social problems.

Due to these reasons it has become important to explore and develop nonconventional energy resources to reduce too much dependence on conventional resources. However, the present trend of developments of non-conventional sources indicate that these will serve as supplement rather than substitute for conventional sources for some more time to come.
Realizing the importance of non-conventional energy sources, in March 1981 the government of India established a Commission for Additional Sources of Energy (CASE) in the Department of Science and Technology, on the lines of the Space and Atomic Energy Commissions.

Energy Chain

The energy available from primary energy source is known as raw energy. This energy undergoes one or more transformation stages before supplying to consumer. The sequence of energy transformations between primary and secondary energy (usable energy) is known as energy chain or energy route.

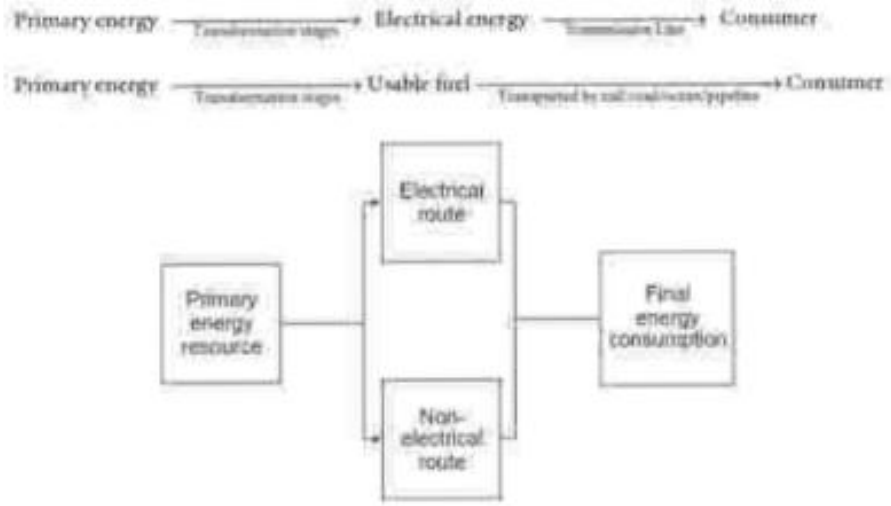

Figure 1.3 Energy routes

Common forms of Energy

1. Electrical Energy
2. Mechanical Energy
3. Thermal Energy
4. Chemical Energy

Advantages and disadvantages of Conventional Energy Sources

Advantages

1. Cost : At present these are cheaper than non-conventional sources.
2. Security : As storage is easy and convenient, by storing certain quantity, the energy availability can be ensured for certain period.
3. Convenience: These sources are very convenient to use as technology for their conversion and use is universally available.

Disadvantages

1. Fossil fuels generate pollutants. Main pollutants generated in the use of these sources are CO, CO_2, NO_x, SO_2, particulate matter and heat. These pollutants degrade the environment, pose health hazards and cause various other problems. CO_x is mainly responsible for global warming also.
2. Coal is also a valuable petro-chemical and is used as raw material for various chemical, pharmaceuticals and paints, etc. industries. From long-term point of view it is desirable to conserve coal for future needs.
3. There are safety and technical issues with nuclear energy. Major problems associated with nuclear energy are as follows:

(a) The waste material generated in nuclear plants has radioactivity of dangerous level; it remains above safe limit for a long period of time and thus is a health hazard. Its safe disposal, which is essential to prevent radioactive pollution, is a challenging task. Also the disposed radioactive waste is required to be guarded for a long period (till its radioactivity level comes down to a safe limit) in order to prevent against going in wrong hands.

(b) Possibility of accidental leakage of radioactive material from reactor (as happened in Chernobyl, former USSR in April 1986)

(c) Uranium resource, for which the technology presently exists, has limited availability.

(d) Sophisticated technology is required for using nuclear resources. Only few countries possess the required expertise to use nuclear energy.

4. Hydroelectric plants are cleanest but large hydro-reservoirs cause following problems:

(a) As large land area submerges into water, it leads to deforestation

(b) Causes ecological disturbances such as earthquakes

(c) Affects wild life
(d) Causes dislocation of large population and their rehabilitation problems

Salient Features of Non-Conventional Energy Sources

Merits

1. Non-conventional sources are available in nature free of cost.
2. They produce no or very little pollution. Thus by and large they are environment friendly.
3. They are inexhaustible(unlimited).

Demerits

1. In general the energy is available in dilute form from these sources.
2. Though available freely in nature the cost of harnessing energy from non-conventional sources is generally high.
3. Uncertainty of availability: the energy flow depends on various natural phenomena beyond human control.
4. Difficulty in transporting this form of energy.
5. Difficulty in storage.

Environmental Aspect of Energy

Greenhouse effect:- Carbon dioxide (CO_2) envelope present around the globe in the atmosphere behaves similar to a glass pane and forms a big global green house. This tends to prevent the escape of heat from earth, which leads to global warming. This phenomenon is known as greenhouse effect.

Apart from CO_2, other gases behaving similar to CO_2 include methane, nitrous oxide (NO),hydro fluorocarbons (HFCs), chlorofluorocarbons (CFCs), hydro chlorofluorocarbons (HCFC), sulphur hexafluoride, ozone and water vapor. These gases are known as greenhouse gases (GHG). Their average concentrations in atmosphere along with Global Warming Potentials (GWPs) relative to CO_2 and atmospheric lifetimes are listed in Table 1.3.

S.N.	Name of the Gas	Concentration in ppm	GWP (100 yr time horizon)	Atmospheric lifetime (yrs)
1.	Carbon dioxide (CO_2)	400	1	100-300
2.	Methane (CH_4)	1.893	28	12
3.	Nitrous oxide (N_2O), commonly known as laughing gas	0.326	265	121
4.	Sulfur hexafluoride (SF_6)	negligible	23,500	3,200

Ex-

A chemical industry produces 5 Tg (teragrams) of NO per day. How much pollution is added into the atmosphere per day in terms of carbon equivalent?

Solution:-The Global Warming Potential (GWP) of NO is 265.

The daily pollution of NO = 5 Tg

The daily pollution in terms of equivalent CO_2 (ref. Table 1.3) = $5 \times 265 = 1{,}325$ Tg = 1,325 Million Tons of CO_2

As (12/44) is the carbon to CO_2molecular weight ratio, the pollution in terms of Million Metric Tons of Carbon Equivalent (MMTCE) = $1{,}325 \times (12/44) = 361.36$ MMTCE

Global Warming:- 'Global warming is the continuing rise in the average temperature of the earth's atmosphere and ocean's surface due to greenhouse effect'.

distances to gas stations where it can be used by consumers. World final energy consumption refers to the fraction of the world's primary energy that is used in its final form by humanity.

In 2014, world primary energy supply amounted to 155,481 terawatt-hour (TWh) or 13,541 million tonne of oil equivalent (Mtoe), while the world final energy consumption was 109,613 TWh or about 29.5% less than the total supply.[11] World final energy consumption includes products as lubricants, asphalt and petrochemicals which have chemical energy content but are not used as fuel. This non-energy use amounted to 9,723 TWh (836 Mtoe) in 2015.[12]

2018 World electricity generation (26,700 TWh) by source (IEA, 2019)[

Coal (38%)
Gas (23%)
Hydro and other (19%)
Nuclear (10%)
Solar PV and wind (7%)
Oil (3%)

Electricity Consumption

The total amount of electricity consumed worldwide was 19,504 TWh in 2013, 16,503 TWh in 2008, 15,105 TWh in 2005, and 12,116 TWh in 2000. By the end of 2014, the total installed electricity generating capacity worldwide was nearly 6.14 TW (million MW) which only includes generation connected to local electricity grids.[16] In addition there is an unknown amount of heat and electricity consumed off-grid by isolated villages and industries. In 2014, the share of world energy consumption for electricity generation by source was coal at 41%, natural gas at 22%, nuclear at 11%, hydro at 16%, other sources (solar, wind, geothermal, biomass, etc.) at 6% and oil at 4%. Coal and natural gas were the most used energy fuels for generating electricity. The world's electricity consumption was 18,608 TWh in 2012.[citation needed] This figure is about 18% smaller than the generated electricity, due to grid losses, storage losses, and self-consumption from power plants (gross generation). Cogeneration (CHP) power stations use some of the heat that is otherwise wasted for use in buildings or in industrial processes.

In 2016 the total world energy came from 80% fossil fuels, 10% biofuels, 5% nuclear and 5% renewable (hydro, wind, solar, geothermal). Only 18% of that total world energy was in the form of electricity.[17] Most of the other 82% was used for heat and transportation.

World total primary energy consumption by fuel in 2018

Coal (27%)
Natural Gas (24%)
Hydro (renewables) (7%)