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EVS 503

Energy Resources

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Department of Forestry and Environmental Science
School of Earth and Environmental Science

Uttarakhand Open University
Haldwani, Nainital (U.K.)

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UNIT: 01: ENERGY AND HUMAN CIVILIZATION

Unit Structure

1.0 Learning Objectives

In this unit you will be able to understand the energy scenario during civilization of human beings including various combinations of technology options and their implications from historical era. The unit will explain:

- The types of energy, forms of energy,
- History of different types of energies used by civilization in the word.
- The current situation of achieving a transition towards sustainable development including a significant role for fossil fuel, renewable, and nuclear energy

1.1 Introduction

Energy used in various forms by the human beings as per the civilization starts as **Sun** was the premitive source in the form of solar energy and then coal was in the form of fossil fuel. Later on people are focused on other options as per the demand of energy. Now a day human are using biomass, wind, water and many more sources in the form of energy. Coal, petroleum, natural gas, photovoltaic and nuclear energies are also using by civilized generations at national and international levels.

As we know that all natural processes and all human actions in the most fundamental physical sense are transformations of energy. The word *energy* derives from the Ancient Greek: *energeia*, lit**. 'activity, operation',** which possibly appears for the first time in the work of **Aristotle** in the 4th century BC. In contrast to the modern definition, energeia was a qualitative philosophical concept, broad enough to include ideas such as happiness and pleasure.

Civilization's advances can be seen as a quest for higher energy use required to produce increased food harvests, to mobilize a greater output and variety of materials, to produce more, and more diverse, goods, to enable higher mobility, and to create access to a virtually unlimited amount of information. In ancient time of terrestrial civilization sun was the ultimate source of energy. This energy was directly used in the production of our food and animal feed. Now in current societies the use of this energy is not only in the cultivation of field crops, trees, fruits, nuts, oil, wood and fuel but also in the conversions of wind flows, water flows to mechanical energy.

Although this conception of energy is recent, we can use it to look back at history. We can characterize the great ages of civilization in terms of the energy extracted and used. Humans (*Homo sapiens*) around 200,000 years ago, and until about 11,000 years ago, lived as foragers, expending energy each day for nourishment. About 5,000 years ago, humans began to build cities, to store food and use water and wind energy in the production of food and goods (Asia, Middle East, Mediterranean, etc.). About 1,500 years ago humans used tools to civilize less-hospitable areas (Northern Europe, etc). About 300 years ago we began to build machines to do real work. About 200 years ago, we began to extract energy rich sources from the earth as coal, petroleum, radioactive elements, etc. (0.1%).

1.2 Civilization of Energy an outlook

- Ancient Greek philosopher Thales discovers static electricity in 600 BCE.


Figure 1: World's largest hydroelectric plant is completed on the Yangtze River in China.

- Ancient Greeks invented gears, a pair of wheels having teeth around the edge that mesh together to magnify the force or speed of a machine, in 400 BCE.
- Water wheels were developed in ancient Rome by an engineer named Vitruvius in 27 BCE. These wheels were early example of turbines that produced the kinetic energy from moving water or air.
- English engineer Thomas Newcomen in 1712, made the first practical steam engine. Steam engines greatly increase the demand for coal.
- Thomas Edison in 1882 opened the world's first major electricity producing power plant.
- German engineer Rudolf Diesel developed the diesel engine in 1890.
- In 2012, world's largest hydroelectric plant is completed on the Yangtze River in China as shown in figure 1.

The concept of Energy: Our modern worldview is constructed around the central concept of Energy. We know that the world as made up of matter and energy. Under the right conditions, they are interchangeable. ($E = mc^2$, where E is energy, m is mass and c is the speed of light). Our modern civilization is founded on the consumption of vast quantities of what we call energy. We use the concept of energy to talk about our social relations, art and culture in general.

Energy is the only universal currency; it is necessary for getting anything done. The conversion of energy on Earth ranges from terra-forming forces of plate tectonics to cumulative erosive effects of raindrops. Life on Earth depends on the photosynthetic conversion of solar energy into plant biomass. Humans have come to rely on many more energy flows—ranging from fossil fuels to photovoltaic generation of electricity—for their civilized existence. Humans are the only species that can systematically harness energies outside their bodies, using the power of their intellect and an enormous variety of artifacts—from the simplest tools to internal combustion engines and nuclear reactors. The epochal transition to fossil fuels affected everything: agriculture, industry, transportation, weapons, communication, economics, urbanization, quality of life, politics, and the environment.

What is Energy?

Now a day by the use of energy we can move cars along the road and boats on the water. It bakes a cake in the oven and keeps ice frozen in the freezer. Energy plays our favorite songs and lights our homes at night. Energy helps our bodies grow and our minds think. Energy is changing, doing, and moving along with working thing. Energy is defined as the ability to produce change or do work and that work can be divided into several main tasks which we can easily recognize. Energy produces light, energy produces heat, energy produces motion, energy produces sound, energy produces growth and energy powers technology, so energy is the basic need of human civilization in current era.

1.3 Forms of Energy

There are various forms of energy which are summarized in figure 2 and also described below:

The major forms of energy are Potential energy and Kinetic energy.

(a) POTENTIAL ENERGY

The stored energy and the energy of position are called potential energy. It is of following types as:

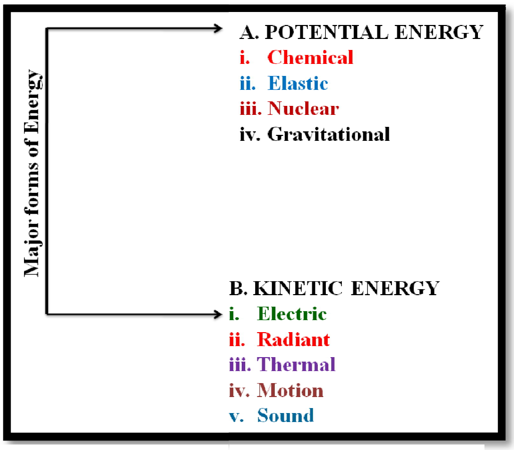

Figure 2: Different forms of Energy

(i)Chemical energy: The energy stored in the bonds of atoms and molecules. It is the energy that holds these particles together. Biomass, petroleum, natural gas, and propane are examples of stored chemical energy. In photosynthesis, sunlight gives plants the energy they need to build complex chemical compounds. When these compounds are later broken down, the stored chemical energy is released as **heat** and **light**.

(ii)Elastic energy: The energy which stored in objects by the application of a force is called elastic energy example: compressed springs and stretched rubber bands.

(iii)Nuclear energy: The energy which stored in the nucleus of an atom or the energy that binds the nucleus of atom together, called nuclear energy. The energy can be released when the nuclei are combined or diffused. The splitting of the nuclei of atoms in nuclear reactor is called fission and combination of the nuclei of hydrogen atoms into helium atoms at sun is called fusion. In both fission and fusion, mass is converted into energy, according to Einstein's Theory, $E = mc^2$.

(iv) Gravitational potential energy: The energy of position or place is called gravitational potential energy, example: hydropower.

(b) KINETIC ENERGY

The motion of waves, electrons, atoms, molecules, substances, and objects found in universe is called kinetic energy .It is of following types as:

(i)Electrical energy: The movement of electrons is called electrical energy. We know that everything is made of atoms and atoms are made of smaller particles called electrons, protons, and neutrons. When electrons move through a wire then it is called electricity e.g.: lightning of bulb.

(ii)Radiant energy: The electromagnetic energy which travels in transverse waves called radiant energy. It includes visible light, x-rays, gamma rays, and radio waves.eg: solar energy.

(iii)Thermal energy: It is also described as heat, is the internal energy in substances. Due to thermal energy the vibration and movement of atoms and molecules takes place within substances. The faster molecules and atoms vibrate and move within a substance, the more energy they possess and the hotter they become. e.g.: geothermal energy.

(iv) Motion energy: It is also called mechanical energy. Motion energy is the movement of objects and substances from one place to another. According to Newton's Laws of Motion, objects and substances move when an unbalanced force is applied. e.g.: Wind.

(v)Sound energy: The movement of energy through substances in longitudinal waves is called sound energy. Sound is produced when a force causes an object or substance to vibrate. The energy is transferred through the substance in a wave. e.g.: musical instruments

Thermodynamics and Energy

Thermodynamics deals with the relationships between heat and other forms of energy. It describes how thermal energy is converted to and from other forms of energy and how it affects matter. First law of thermodynamics is one of the most fundamental laws of nature i.e. the conservation of energy principle.

The First Law of Thermodynamics simply states that during an interaction, energy can change from one form to another but the total amount of energy remains constant. The second law of thermodynamics tells us that energy has quality as well as quantity, and actual processes occur in the direction of decreasing quality of energy. Whenever there is an interaction between energy and matter, thermodynamics is involved.

Examples belong the laws of thermodynamics:

Light bulbs transform electrical energy into light energy (radiant energy). One pool ball hits another, transferring kinetic energy and making the second ball move. Plants convert the energy of sunlight into chemical energy stored in organic molecules during photosynthesis. Transformation of chemical energy into kinetic energy as you walk, breathe.

Other examples belong to law of Conservation of Energy in terms of hydro energy:

Water can produce electricity. Water falls from the higher level, converting potential energy to kinetic energy. This energy is then used to rotate the turbine of a generator to produce electricity. In this process, the potential energy of water in a dam can be turned into kinetic energy which can then become electric energy.

Energy can also be classified into several types based on the following criteria: Primary and Secondary energy, Commercial and Non commercial energy, Renewable and Non-Renewable energy

1.3.1 Primary and Secondary Energy

Primary energy sources are those that are either found or stored in nature. Common primary energy sources are coal, oil, natural gas, and biomass (such as wood). Primary energy sources are mostly converted in industrial utilities into secondary energy sources; for example coal, oil or gas converted into steam and electricity. Primary energy can also be used directly. Some energy sources have non-energy uses, for example coal or natural gas can be used as a feedstock in fertilizer plants.

1.3.2 Commercial Energy and Non Commercial Energy:

The energy sources that are available in the market for a definite price are known as commercial energy. The most important forms of commercial energy are electricity, coal and refined petroleum products. Commercial energy forms the basis of industrial, agricultural, transport and commercial development in the modern world. In the industrialized countries, commercialized fuels are predominant source not only for economic production, but also for many household tasks of general population.

Non-Commercial Energy: The energy sources that are not available in the commercial market for a price are classified as non-commercial energy. 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. These are also called traditional fuels.

1.4. Resources of energy

These are of following types:

i) Conventional energy sources

ii) Non Conventional energy sources

i) Conventional energy sources:

These resources were used in historic era as; most of the fuel wood was consumed for domestic purposes. Thermal coal also used at large scale during the passing of time. **After world war**–II yet another source of energy, nuclear power was developed. All these sources of energy are known as conventional sources of energy, among which coal still occupies a central position.

Conventional or Non renewable energy sources commonly come under fossil fuels as:

1) Coal

2) Petroleum

3) Natural gas

4) Peak Oil

5) Shale Oil

ii) Non Conventional energy sources: By passing of time efforts were made to develop new sources of energy during civilization. These are called non-conventional sources of energy and include urban waste, agriculture waste, energy plantations, animal and human wastes, solar energy, wind-energy, tidal energy, geothermal energy, ocean, biogas etc. These are pollution-free, environmentally clean and socially relevant.

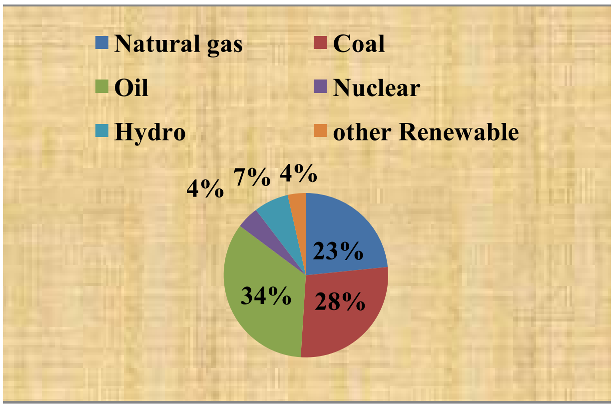

Figure 3: World energy consumption (source: BP statistical review of world energy, 2018)

The energy which comes from natural resources such as sunlight, wind, rain, tides, and geothermal heat is called renewable energy. In 2008, about 19% of global final energy consumption came from renewable, with 13% coming from traditional biomass, which is mainly used for heating, and 3.2% from hydroelectricity. **New renewable** are small hydro, modern biomass, wind, solar, geothermal, and bio-fuels accounted for another 2.7% and are growing very rapidly. The share of renewable in electricity generation is around 18%, with 15% of global electricity coming from hydroelectricity and 3% from new renewable in current past years (World energy, 2018)

The energy taken from a source which is depleted by extraction is called resource energy or non-renewable energy. Non-renewable energy sources come from the earth and appear as solids, liquids, and gases. Different forms of energy sources used in the world to produce energy are shown in figure 3.

Fossil fuel: Fossil fuels are fuels formed by natural resources such as anaerobic decomposition of buried dead organisms. The age of the organisms and their resulting fossil fuels is typically millions of years and sometimes exceeds 650 million years. The fossil fuels, which contain high percentages of carbon, include coal, petroleum, and natural gas. Fossil fuels range from volatile materials with low carbon: hydrogen ratios like methane, to liquid petroleum to nonvolatile materials composed of almost pure carbon, like anthracite coal.

Methane can be found in hydrocarbon fields, alone associated with oil, or in the form of methane clathrates. It is generally accepted that they formed from the fossilized remains of dead plants and animals by exposure to heat and pressure in the Earth's crust over millions of years.

Coal: A combustible black or brownish-black sedimentary rock normally occurring in rock strata in layers or veins called coal beds or coal seams. Coal is composed primarily of carbon along with variable quantities of other elements, chiefly sulfur, hydrogen, oxygen and nitrogen. Coal begins as layers of plant matter accumulate at the bottom of a body of water. For the process to continue the plant matter must be protected from biodegradation and oxidization, usually by mud or acidic water. Formation of coal is shown in figure 4.

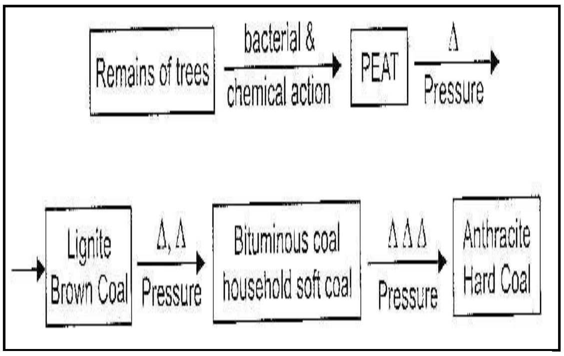

Figure 4: Flow chart for the Formation of coal

As geological processes by passing of time apply pressure to dead biotic material and the conversions goes as follows:

Peat, a precursor of coal

Lignite, or brown coal, the lowest rank of coal, most harmful to health, used almost exclusively as fuel for electric power generation

Bituminous coal, a dense sedimentary rock, usually black, but sometimes dark brown, often with well-defined bands of bright and dull material It is used primarily as fuel in steam-electric power generation and to make coke.

Anthracite, the highest rank of coal is a harder, glossy black coal used primarily for residential and commercial space heating.

1.4.1. Human Civilization with Coal Energy

We know that coal was an ancient source of energy, used by the Chinese to smelt metals and discussed by Aristotle. Use of coal, however, was always fairly modest by modern standards. The production of coal began to increase when it became the energy source of the first industrial revolution.

British production of coal increased from 1750 to 1830. The American industrial revolution was based on the availability of cheap anthracite coal in the 1830. Coal was used for heating buildings, smelting iron into steel, and driving steam engines. Early extraction techniques such as bell pits would generally only recover a relatively small percentage of the in-place coal. For example, in Tyneside the pits extracted only approximately 40% of the available coal. The figure showing a coal powered steam engine (1880) with world's first electric generator.

The steam engine, combined with coal, made possible the transformation of this cheap source of heat into work. Steam engines were used to power factories and locomotives. They were the driving mechanism behind the first industrial revolution, beginning in England, then moving on to the US and the rest of the world.

1.4.2. Petroleum

Petroleum or crude oil is a naturally occurring, flammable liquid consisting of a complex mixture of hydrocarbons of various molecular weights and other liquid organic compounds that are found in geologic formations beneath the Earth's surface. Petroleum, from Greek: Petra means rock + Latin: Oleum means oil. Petroleum is recovered mostly through oil drilling. The term petroleum was first used in the treatise De Natura Fossilium , published in 1546 by the German mineralogist Georg Bauer, also known as Georgius Agricola. In the 19th Century, the term petroleum was frequently used to refer to mineral oils produced by distillation from mined organic solids such as coal.

Composition of Petroleum

Petroleum includes not only crude oil, but all liquid, gaseous and solid hydrocarbons. In an underground oil reservoir the proportions of gas, liquid, and solid depend on subsurface conditions.

The hydrocarbons in crude oil are mostly alkanes, cycloalkanes and various aromatic hydrocarbons, while the other organic compounds contain nitrogen, oxygen and sulfur, and trace amounts of metals such as iron, nickel, copper and vanadium. Under surface pressure and temperature conditions, lighter hydrocarbons methane, ethane, propane and butane exist as gases, while pentane and heavier hydrocarbons are in the form of liquids or solids. Many oil reservoirs contain live bacteria. The exact molecular composition of crude oil varies widely from formation to formation as shown in figure 5.

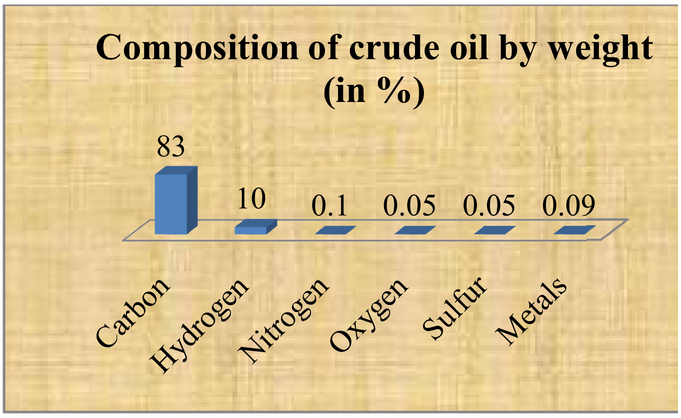

Figure-5: Composition of different elements in crude oil

In crude oil four different types of hydrocarbon molecules appear. The percentage of each varies from oil to oil as:

Composition by weight (source: Sharma, 2018)

Hydrocarbon	Average	Range
Alkanes (paraffins)	30%	15 to 60%
Naphthenes	49%	30 to 60%
Aromatics	15%	3 to 30%
Asphaltics	6%	remainder

Crude oil varies greatly in its composition. It may be yellowish, reddish, or even greenish or it is usually black or dark brown. Petroleum is converted into energy-rich fuels including gasoline, diesel, jet, heating and other fuel oils. Petroleum is found in porous rock formations in the upper strata of some areas of the Earth's crust. There is also petroleum in oil sands (tar sands).

Due to its high energy density, easy transportability and relative abundance, oil has become the world's most important source of energy since the mid-1950. Petroleum is also the raw material for many chemical products,

including pharmaceuticals, solvents, fertilizers, pesticides, and plastics; the 16 percent not used for energy production is converted into these other materials.

1.4.3. Human Civilization with Petroleum Energy

Large-scale oil extraction began in the late 19th century, and along with electricity, became one of the driving forces of the second industrial revolution. Oil is about 50% higher in energy density than coal and it is easier to transport and store. The invention of the internal combustion engine opened up a large market for petroleum. The success of the internal combustion engine did not, however, mean the end of steam. Steam was used to drive the turbines in the first large electrical generators. Indeed, steam still drives the turbines in nuclear power plants. Figures show the production and consumption of oil using by world in past and future.

Now we will study the human civilization with history of petroleum in different phases as:

History of petroleum, Phase One:

In ancient civilization as in Roman, Persian and China petroleum was used in the form of crude oil. All of these civilizations burned crude oil directly in the form of fuel. The modern history begins with the refining of kerosene and general processes of fractionation by distillation (Ali, 2019). Around this time the first commercial wells were drilled. Early on, the industry was driven by a demand for kerosene and oil lamps. The development of the electrical grid, however, began to destroy the market for kerosene (Sharma, 2018).

History of petroleum, Phase Two

It started in the early part of the 20th century, due to the increasing availability of automobiles demand. For constant supply of fuel the network of filling stations were made on large scales. World War I changed the role of petroleum in the world drastically as Britain entered the war with only 800 motor vehicles, but had 56,000 trucks and 36,000 cars by the end. The US shipped over 50,000 vehicles and built 15,000 planes (Sharma, 2008)

History of petroleum, Phase Three and Four

By passing the time, crude oil continues to be one of the core components of modern life, providing most of the energy for our contemporary societies. Oil indulges in economic prosperity and quality of life. Access to oil means power and control. We now have a large energy gap between wealthy and poor nations. The role of oil, has sometimes lead to concentration of wealth and power in just a few individuals or institutions. Union of Soviet Socialist Republics (USSR) under Stalin, China under Mao Zedong, the Saudi family, the Shah of Iran during the 70s, etc. State ownership of utilities, subsidization of production, manipulation of prices, high taxation of use, etc.

The desire of oil consuming nations to secure their supplies in the Middle East has lead to much interference in the region as:

Soviet invasion of Iran (1945-46)

US troops to Lebanon (1958, 1982)

Western and Soviet arms sales.

Western support for Iraq.

The Iraq Wars (1990-1991, 2003-2010).

Support to Libyan rebels (2011), etc.

1.4.4. Natural gas

Natural gas is a gas consisting primarily of methane, typically with 0-20% higher hydrocarbons . It is found associated with other fossil fuels and is an important fuel source for major feedstock for fertilizers. Most natural gas is created by two mechanisms: **biogenic** and **thermogenic**. **Biogenic** gas is created by methanogenic organisms in marshes, bogs, landfills, and shallow sediments. Deeper in the earth, at greater temperature and pressure, **thermogenic** gas is created from buried organic material. Before natural gas can be used as a fuel, it must undergo processing to remove almost all materials other than methane.

Natural gas is a naturally occurring hydrocarbon gas mixture consisting primarily of methane, but commonly including varying amounts of other higher alkanes, and sometimes a small percentage of carbon dioxide, nitrogen, hydrogen sulfide, or helium. It is formed when layers of decomposing plant and animal matter are exposed to intense heat and pressure under the surface of the Earth over millions of years. The energy that the plants originally obtained from the sun is stored in the form of chemical bonds in the gas.

Natural gas is a naturally occurring hydrocarbon used as a source of energy for heating, cooking, and electricity generation. It is also used as a fuel for vehicles and as a chemical feedstock in the manufacture of plastics and other commercially important organic chemicals. Natural gas is called a non-renewable resource.

In petroleum production gas is often burnt as flare gas. The World Bank estimates that over 150 cubic kilometers of natural gas are flared or vented annually. Before natural gas can be used as a fuel, most, but not all, must be processed to remove impurities, including water, to meet the specifications of marketable natural gas.

Natural gas is often informally referred to simply as "gas", especially when compared to other energy sources such as oil or coal. However, it is not to be confused with gasoline, especially in North America, where the term gasoline is often shortened in colloquial usage to gas.

How do we find natural gas?

The search for natural gas begins with geologists who study the structure and processes of the earth. They locate the types of geologic formations that are likely to contain natural gas deposits.

Geologists often use **seismic surveys** on land and in the ocean to find the right places to drill natural gas and oil wells. Seismic surveys create and measure seismic waves in the earth to get information on the geology of rock formations. Seismic surveys on land may use a *thumper truck*, which has a vibrating pad that pounds the ground to create seismic waves in the underlying rock. Sometimes small amounts of explosives are used. Seismic surveys conducted in the ocean use blasts of sound that create sonic waves to explore the geology beneath the ocean floor.

If the results of seismic surveys indicate that a site has potential for producing natural gas, an exploratory well is drilled and tested. The results of the test provide information on the quality and quantity of natural gas available in the resource.

In the United States and in a few other countries, natural gas is produced from shale and other types of sedimentary rock formations by forcing water, chemicals, and sand down a well under high pressure. This process, called ***hydraulic fracturing*** or ***fracking***, and sometimes referred to as unconventional production. At the top of the well on the surface, natural gas is put into gathering pipelines and sent to natural gas processing plants.

Natural Gas with civilization:

By searching natural gas it has been found by different mining engineers (geologists) that in some places, natural gas moved into large cracks and spaces between layers of overlying rock. Civilization hints that the natural gas found in these types of formations is sometimes called **conventional natural gas**. In other places, natural gas occurs in the tiny pores (spaces) within some formations of shale, sandstone, and other types of sedimentary rock. This natural gas is referred to as ***shale gas*** or ***tight gas,*** and it is sometimes called **unconventional natural gas**. Natural gas also occurs with deposits of crude oil, and this natural gas is called associated natural gas. Natural gas deposits are found on land and some are offshore and deep under the ocean floor. Here we have the figure, in which the production of natural gas in past and future.

1.4.5. Peak Oil and Civilization

Peak oil is a concept that was developed by M. King Hubbert, in 1956, to describe the point in time when the maximum rate of oil production is reached, after which production goes into decline. This is both a local and a global concept. Hubbert noted that after discovery, production in an oil region begins to climb at an accelerated rate and he modeled this growth to predict when production would peak and the region would go into decline. He was successfully able to predict that US oil production would peak in the late 1960s.

1.4.6. Shale Oil and civilization

Shale oil is unconventional oil produced from oil shale rock fragments by **pyrolysis**, **hydrogenation**, or **thermal dissolution**. These processes convert the organic matter within the rock (kerogen) into synthetic oil and gas. The resulting oil can be used immediately as a fuel or upgraded to meet refinery feedstock specifications by adding hydrogen and removing impurities such as sulfur and nitrogen. The refined products can be used for the same purposes as those derived from crude oil.

New techniques used for extracting oil are known as **hydraulic fracking** and have lead to new reserves of crude oil and natural gas being declared. For example, North Dakota, which started producing in 2006, was producing almost as much crude as Texas until 2014. There are, however, environmental costs to developing these types of energy sources. Production itself produces contaminants that might harm the local land and water. Water containing toxins is pumped back into the ground as part of the process.

The term "shale oil" is also used for crude oil produced from shales of other very low permeability formations. However, to reduce the risk of confusion of shale oil produced from oil shale with crude oil in oil-bearing shales, the term "tight oil" is preferred for the latter. The International Energy Agency recommends to use the term "light tight oil" and World Energy Resources 2013 report by the World Energy Council uses the term "tight oil" for crude oil in oil-bearing shales.

1.5. SUMMARY

In this unit we have discussed about different levels of human civilization in terms of energy history.

This unit is also able to describe the history of energy with human civilization as the use of energy in the form of sun from ancient time also made an overview that the radiant energy of sun was the ultimate source of energy on earth.

Several types of energy sources as conventional and non conventional were used by civilization of the world at different levels along with different forms of energies.

Evolution of agriculture can be seen as a continuing effort to raise land productivity, in order to accommodate larger populations, so to meet out that burning demand of energy so, nonconventional sources of energy were also came in origin.

Modern civilization depends on extracting prodigious energy stores, depleting finite fossil fuel deposits that cannot be replenished even on time scales orders of magnitude longer than the existence of our species.

Our expansion into oil consumption didn't begin until around 1870. Two decades later it was followed by natural gas and hydroelectricity. By 1900, coal consumption had increased significantly, accounting for almost half of global energy,the other half remaining biomass, since oil, gas and hydroelectricity remained small.

Reliance on nuclear fission and the harnessing of renewable energies (adding wind- and photovoltaic-generated electricity to more than 130-year-old hydrogeneration, and turning to new ways of converting phytomass to fuels) have been increasing, but by 2015 fossil fuels still accounted for 86% of the world's primary energy.

The generation, transmission and use of electricity were unparalleled achievements in energy innovation.

The practical use of fuel current required the invention and instillation of a new technological system.

Thomas Edison and other system builders used their vision, determination and organizational talent to make electricity a practical reality.

The ready availability of cheap electricity has transformed the modern world civilization, and along with petroleum, forms the energy backbone of modern life of civilization from the part of history.

Terminal Questions

Q.1.) Fill in the blanks:

Energy used in various forms by the ……… beings as per the ………… starts as sunwas the………………in the form of ………. energy and then coal wasin the form of …….. fuel. Later on people are focused on other options as per the demand of ………. Now a day human are using ……….., wind, water and many more sources in the form of energy. Coal, ………, Natural gas, ……….. and nuclear energies are also using by ……….. peoples at national and ………… levels.

Q.2.) What do you mean by Primary and Secondary Energy?

Q.3.) Describe Human Civilization with Coal Energy.

Q.4.) Explain Different phases of petroleum with human civilization.

Q.5.) What is meant by Fossil fuel?

Q.6.) Explain history of natural gas with human civilization.

Q.7.) Fill in the blanks:

We know that ……… was an ancient source of energy, used by the ……….. to smelt ……… and discussed by ………. Use of coal, however, was always fairly modest by modern standards. The production of coal began to ………… when it became the energy source of the first industrial ………….. British production of coal increased from 1750 to 1830. The American industrial revolution was based on the availability of cheap …………

coal in the ……….. Coal was used for heating buildings, ……………. iron into steel, and driving steam engines. Early ……………….. techniques such as bell pits would generally only recover a relatively small percentage of the in-place coal. For example, in Tyneside the pits extracted only approximately 40% of the available coal.

Q.8.) Explain different forms of Energy.

Q.9.) Explain forms of natural gas along with civilization.

Answers:

Q.1.) human, civilization , primitive source , solar , fossil , energy, biomass, petroleum, photovoltaic, civilized, international.

Q.2.) Pls . refer 1.3.1

Q.3.) Pls . refer 1.4.1

Q.4.) Pls . refer 1.4.3

Q.5.) Pls . refer 1.3.2

Q.6.) Pls . refer 1.4.4

Q.7.) coal, Chinese, metals, Aristotle, increase, revolution, anthracite, 1830,. smelting, extraction.

Q.8.) Pls . refer 1.3.2

Q.9.) Pls . refer 1.4.7

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UNIT-2: ENERGY PRODUCTION AND CONSUMPTION

Unit Structure

2.0 Learning Objectives

"The current situation of the demand and supply of energy Ratio of Energy Production, Elasticity Ratio of Electricity Production, Elasticity Ratio of Energy Consumption, Elasticity Ratio of Electricity Consumption and Efficiency of Energy Processing are also discussed". In this unit you will be able to understand:

- The production and consumption of energy at different levels as at National and Global levels.
- Different technologies used by developing and developed countries.
- This unit is highly focused on the energy from non conventional energy sources and conventional energy sources apart from that you will also be able to understand the consumption of various energy forms on international and national platform.

2.1: Introduction

Energy is one of the major inputs for the economic development of any country. For the same the combination must be balanced in demand and supply. In the case of the developing countries, the energy sector assumes a critical importance of production in view of the ever increasing energy needs requiring huge investments to meet them. The energy resources in different forms as coal, crude oil, natural gas, photovoltaic and nuclear power are used by population at national and international levels. So, total energy production is a comprehensive indicator to show the capacity, scale, composition and development of energy production of the country. The production of primary energy includes that of coal, crude oil, natural gas, hydro-power, bio-energy and solar energy.

The total consumption of energy of various kinds is a comprehensive indicator to show the scale, composition and development of energy consumption. The total energy consumption includes coal, crude oil and their products, natural gas, bio-energy and solar energy.

2.2. Energy Scenario at different levels:

To know the actual energy scenario the following measurements are necessary as:

Final energy consumption, Loss during the Process of Energy Conversion, Energy Loss, Elasticity Ratio of Energy Production, Elasticity Ratio of Electricity Production, Elasticity Ratio of Energy Consumption, Elasticity Ratio of Electricity Consumption and Efficiency of Energy Processing. The details are as follows:

(1) Final Energy Consumption: It refers to the total energy consumption by material production sectors, non material production sectors and households in the country (region) in a given period of time, but excludes the consumption in conversion of the primary energy into the secondary energy and the loss in the process of energy conversion.

(2) Loss during the Process of Energy Conversion: It refers to the total input of various kinds of energy for conversion, minus the total output of various kinds of energy in the country in a given period of time. It is an indicator to show the loss that occurs during the process of energy conversion.

(3) Energy Loss: It refers to the total of the loss of energy during the course of energy transport, distribution and storage and the loss caused by any objective reason in a given period of time. The loss of various kinds of gas due to gas discharges and stocktaking is excluded.

Elasticity Ratio of Energy Production is an indicator to show the relationship between the growth rate of energy production and the growth rate of the national economy.

The formula for the same is:

$$\textbf{Elasticity Ratio of Energy Production} = \frac{\text{Average Annual Growth Rate of Energy Production}}{\text{Average Annual Growth Rate of National Economy}}$$

The average annual growth rate of the national economy can be shown by the gross national product, gross domestic product and other indicators, depending upon the purposes or needs.

Elasticity Ratio of Electricity Production is an indicator to show the relationship between the growth rate of electricity production and the growth rate of the national economy. Its formula is:

$$\textbf{Elasticity Ratio of Electricity Production} = \frac{\text{Average Annual Growth Rate of Electricity Production}}{\text{Average Annual Growth Rate of National Economy}}$$

Elasticity Ratio of Energy Consumption is an indicator to show the relationship between the growth rate of energy consumption and the growth rate of the national economy. The formula for the same is:

$$\textbf{Elasticity Ratio of Energy Consumption} = \frac{\text{Average Annual Growth Rate of Energy Consumption}}{\text{Average Annual Growth Rate of National Economy}}$$

Elasticity Ratio of Electricity Consumption is an indicator to show the relationship between the growth rate of electricity consumption and the growth rate of the national economy. The formula for the same is:

$$\textbf{Elasticity Ratio of Electricity Consumption} = \frac{\text{Average Annual Growth Rate of Electricity}}{\text{Average Annual Growth Rate of National Economy}}$$

Efficiency of Energy Processing and Conversion refers to the ratio of the total output of energy products of various kinds after processing and conversion and the total input of energy of various kinds for processing and conversion in the same reference period. It is an important indicator to show the current conditions of energy processing and conversion equipment, production technique and management. The formula for the same is:

$$\textbf{Efficiency of Energy Processing \& Conversion} = \frac{\text{Output of Energy After Processing } \& \ Conversion}{\text{Input of Energy for Processing } \& \ Conversion} \textbf{ X 100}$$

Currently the production and consumption increased by population in the form of renewable sources of energy. The production of energy renewable and -from non renewable sourcesin various forms is shown in figure as :

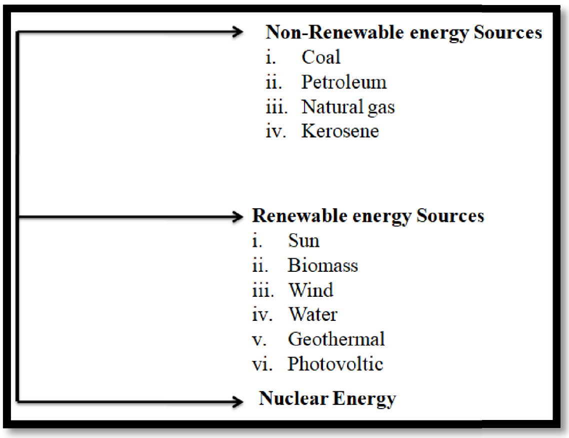

Figure 1: Various sources of energy.

2.3. Energy Production from Non-renewable energy sources

We know that earth has rich sources of non renewable energy in different forms. These sources are using for the production of various forms of energy in different parts of world. The production of Non-renewable energy and renewable energy is as follows:

(A) Production of Coal: We know that coal is biggest single source of energy for the production of electricity. It is combustible in nature and black to brown in color which contains carbon and hydrocarbons as main constituents in it. It is most abundant fossil fuel produced in U.S.A. The energy in coal comes from the energy stored by plants that lived hundreds of millions of years agow ,when the earth was partly covered with swampy forests. For millions of years, a layer of dead plants at the bottom of the swamps was covered by layers of water and dirt, trapping the energy of the dead plant. Temperature and pressure helps in coalification process. It takes millions of years to createcoal . Coal energy usesin the production of electricity and steel industries. Coal is produced in coal mines and transported on mega scale.

China: China has been by far the biggest coal producing country over the last three decades. The country produced about 3.6 billion tonnes (Bt) of coal for over 47% of the world's total coal output. China contains world's third biggest coal reserves, estimated at 114.5Bt as of December 2012 with around 12,000 coal producing mines (Sharma, P.D, 2019)

The United States: The United States, the world's second biggest coal producing country, produced about922Mt of coal for more than 13% of the world's coal production. Coal mining occurs in 25 states of which Wyoming, West Virginia, Kentucky, Pennsylvania and Texas are the biggest coal producers. (Sharma, PD)

India: India produced approximately 605Mt of coaland becoming the third biggest coal producer in the world. India's proven coal reserves are third biggest reservesin the world. The four eastern Indian states Jharkhand, Chhattisgarh, Orissa and West Bengal account for about 70% of the country's coal reserves. Andhra Pradesh, Madhya Pradesh and Maharashtra are the other leading coal producing states in India.

Indonesia: Indonesia produced 386Mt of coal andmaking it the world's fifth largest coal producing country. Indonesia uses coal to produce approximately 44% of its electricity. The East Kalimantan region is the biggest coal producing region and accounts for about two thirds of Indonesia's coal output dan mostly located in Sumatra, East Kalimantan and South Kalimantan. (**Sharma, PD)**

Russia: Russia, with 354.8Mt of coal output is the sixth biggest coal producing country in the world. Steam coal accounted for 80% of the total coal output while the rest 20% was coking coal. The country holds the world's second biggest proven coal reserves, estimated at 157Bt. The Kuzbass region contributing over 200Mt of coal output is the biggest coal producing region in Russia. (**Sharma, 2018)**

South Africa: Coal output, estimated at 280Mt made South Africa the seventh biggest coal producing country. South Africa is also the world's sixth biggest coal exporting country; exporting 74Mt of coal. South Africa's coal exports are mostly made to China, India and Europe. The African country depends on coal for more than 90% of its electricity generation.

Germany: The world's eighth biggest coal producing country, Germany produced 196.2Mt of coal. The country's brown coal production, estimated at more than 180Mt, makes it the world's biggest brown coal producer followed by Russia and Australia. About 43% of Germany's electricity generation is coal-based. More than 75% of the country's hard coal production comes from the Ruhr Coal Basin in the North Rhine-Westphalia state and the

Saar Basin in the south-west Germany, whereas the Rhineland region hosts the country's biggest lignite deposits (**Sharma, 2018).**

Poland: Poland produced 144.1Mt of coal becoming the world's ninth biggest coal producing country and Europe's second biggest coal producer after Germany. More than 85% of Poland's electricity generation is based on coal. Kompania Weglowa is Poland's biggest coal mining company followed by Lubelski Wegiel Bogdanka (**Sharma, 2018).**

Kazakhstan: Kazakhstan, with 116.6Mt of coal output stands as the world's tenth biggest coal producing country. Coal accounted for about 85% of the country's total installed power capacity. Kazakhstan holds the world's eighth biggest proven coal reserves, estimated at 33.6Bt. Karaganda and Ekibastuz are the two major coal producing basins in the country. Bogatyr Access Komir is the biggest open cast mining company in Kazakhstan (**Sharma, 2018).**

(B) Production of petroleum(Crude oil) **:** It is also known as crude oil. It is naturally occurring flammable liquid and having the mixture of hydrocarbons of low and high molecular mass. It is recovered through oil drilling andthen refinedDuring . refining various byproducts recovered. Crude oil is approximately 50% higher in energy density than coal. Top oil producing countries of the world are United States, Saudi Arabia, Russia, Canada, China, Iran Iraq, United Arab Emirates, Brazil and Kuwait. The reservoirs through which crude oil is drilled are found globally in the countries as in Venezuela, Saudi Arabia, Canada, Iran, Iraq, Kuwait, U.A.E., Russia and Libya etc. The quantity of crude oil is measured in million barrels (mb). (**Sharma, 2018)**

The Largest Oil Producing Countries: The largest oil producing countries of the world are described below:

USA: In the year 2017 USA was the top producer of crude oil, which represented about 13.4% of the world's total oil output. Energy Information Administration (EIA) predicts that crude oil production in the USA was expected to be more than 10 million barrels per day (b/d) early in 2018, reaching that milestone for the first time since 1970. The USA remains arguably the most influential among this list of the top oil producing countries in the world.

Saudi Arabia: This country is one of the top oil producing countries in the world. Saudi Arabia possesses 260 billion barrels of oil reserves; accounting for around 22% of the world's proven petroleum reserves and ranks as the largest exporter of petroleum. The oil and gas sector in Saudi Arabia accounts for about 50% of the country GDP, and about 85% of export earnings (**Sharma, 2018)**

UAE: The UAE has one of the largest oil reserves in the world. The UAE government has announced that they will increase the production of their oil to 5 million b/d in coming years. The major oil reserves in the UAE are in the regions of Abu Dhabi, Dubai, and in Sharjah.

Canada: Currently, Canada's main sources of oil production are the oil sands located in Alberta, the Western Canada Sedimentary Basin and Atlantic offshore fields. According to the EIA, Canada's oil production could grow by 1.26 million b/d by 2040 (**Sharma, 2018).**

China: China is one of the world's largest oil markets in terms of oil production and also one of the top oil consuming countries in the world. Currently, China is one of the leaders in the world top oil producing countries and represents around 4.7% of the global oil output. With its huge population and booming economy, the energy demand still remains high.

Iran: Iran is one of the largest oil producing countries in the Middle East and second-largest oil exporter in the group of the organization of petroleum exporting countries. Iran has significantly increased its oil production capacity from 3.5 million b/d in 2004 to over 3.7 million b/d in 2017. The oil production in Iran is one of their major industries that employee majority of Iranian. The total revenue generated from oil production in Iran is over 60% of the total government revenues. ((**Sharma, 2018))**

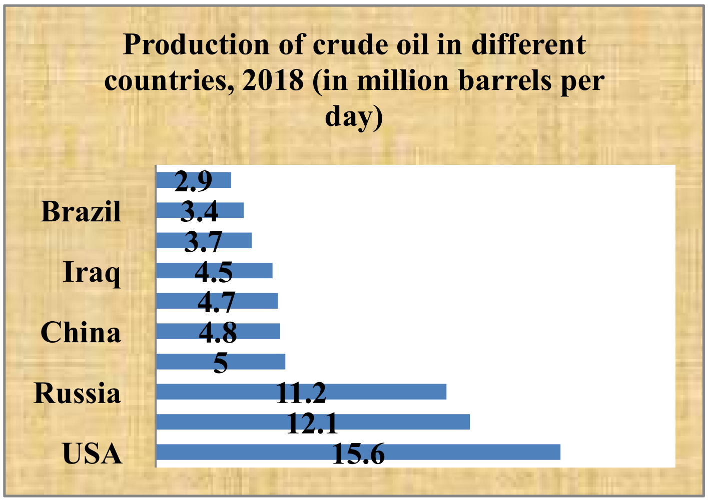

Figure-2: Oil Producing Countries in the World, 2018

Iraq: Iraq has the world's fifth largest petroleum reserve and it is currently world's 7th largest petroleum producing nation. Iraq's economy is majorly depended on its oil production and imports. More than 90% of the energy generated in the country is from petroleum products. ((**Sharma, 2018))**

Russia: Russia has the eighth largest oil reserves in the world, it is also one of the top oil exporting countries in the world. In 2016, Russia exported more than 5.2 million barrels per day (b/d) of crude oil and condensate and more than 2.4 million b/d of petroleum products, mostly to countries in Europe. Exports of crude oil and petroleum products represented nearly 70% of total Russian petroleum liquids production in 2017.

Brazil: Brazil is the largest producer of crude oil in the whole South American region. The production of oil in Brazil has increased by over 5% year over year. With the rising demand in the international market, the Brazilian government has now increased the imports of oil. ((**World Energy report, 2018))**

Kuwait: Kuwait's oil production currently stands out at 2.9 million b/d, and with the growing competition in the Middle East, Kuwait is expected to increase its production by 6 million b/d in coming years. The petroleum industry in Kuwait is the largest industry in the country accounting for over half of its GDP. Kuwait oil reserves are 4th largest in the world with 9.5% of the global reserve. See the figure 2 for the same (**World Energy report, 2018).**

(C) Production of Natural Gas:

Natural gas is a very demanding energy source in the form of fuel which is used in the production of electricity. As coal is the cheapest fossil fuel on earth but it has several pollutants which emits during

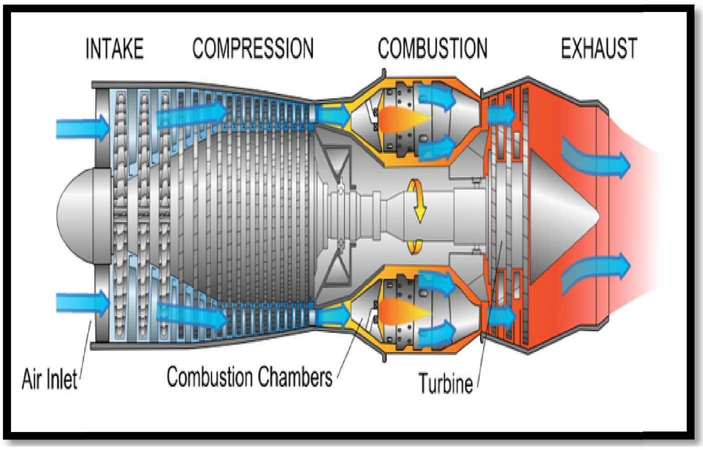

Figure: 3: The gas turbine engine for the production of electricity

combustion. So the requirements of clean energy source come in origin in the form of natural gas. It is environmental friendly in nature and used as clean energy source in the production of electricity.

Natural Gas power plant: It generates energy by burning natural gas in the form of its fuel. There are many types of natural gas power plants which all generate electricity. The natural gas plants use gas turbine. In them the natural gas is added, along with a stream of air, which combusts and expands through this turbine causing a generator to spin a magnet for making electricity. The operation of natural gas power plant is shown in figure.

Operation of Natural gas power plants: Natural gas turbines are theoretically simple and have three main parts as:

1. Compressor: It takes air from outside of the turbine and increases its pressure.

2. Combustor: In it burning of fuel takes place along with production of high pressure and high velocity gas.

3. Turbine: It extracts the energy from the gas coming from the combustor. See gas turbine engine with main parts in figure 3.

Natural gas power plants are cheap and quick to build. Despite the improved air quality, natural gas plants significantly contribute to climate change, and that contribution is growing. The world largest natural gas power plant, Surgut-2 is situated in Russia.

(D) Production of Kerosene:

It is a derivative of petroleum and called lamp oil or coal oil. Kerosene is used as fuel in houses and industries. The major components of it are branched and straight chain **alkanes** and **naphthenes**. In India and Nigeria kerosene is the main fuel for cooking in portable stoves and in agriculture. It is the distilled product of refined petroleum with other fractions as fuel oil, lubricating oil and grease.

Before millions of years the organic residue was converted to petroleum by a pair of complex chemical processes known as diagenesis and catagenesis. **Diagenesis** occurs below 122^0 F, and involves both microbial activity and chemical reactions as dehydration, condensation, cyclization, and polymerization where as **catagenesis** occurs between 122^0F and 392^0F. It involves catalytic cracking, decarboxylation and hydrogen disproportionation. So in production of kerosene first step is to collect the crude oil by drilling which is separated into its components before turning into kerosene. Distilled long column is used for this process and the purification occurs. After extraction refined kerosene stored in tanks for use. ((**World Energy report, 2018))**

2.4. Energy Production from renewable energy sources

Production from Sun: The most primitive source of energy which was used by human beings is solar energy. It is radiant light and heat of sun. Solar energy production techniques include solar heating, solar **photovoltaic**, concentrated solar power and solar architecture.

The International Energy Agency projected that solar power will be the third largest source of energy after 2060. Solar energy is active and passive in nature. In active solar technique the use of photovoltaic systems are used and in passive solar technique the orientation of a building to the sun takes place by selecting the materials with favorable thermal mass.

The eight biggest solar power plants in the world by installed capacity.

Table:1- Different sources of biomass and forms of energy

S.No	Sources of biomass	Forms of biomass	Conversion process	Forms of energy
1	Silviculture	Fire wood	Combustion	Heat
2	Agriculture	Carbohydrates	Fermentation	Ethanol
3	Weeds	Whole plant body	Fermentation	Methane
4	Rural/urban wastes/ industrial wastes	Wastes	Combustion Pyrolysis	Fire/fuel Fuel oil
5	Cattle dung	Wastes	Fermentation (biomass)	Methane

Production from Wind:

The energy produced by wind is called wind energy or wind power. Wind is used to generate electricity. Wind turbines convert the kinetic energy of the wind into mechanical power. A generator can convert mechanical power into electricity. Mechanical power can also be utilized directly for specific tasks such as pumping water. Wind is depending on the uneven heating of the atmosphere by the sun, variations in the earth's surface, and rotation of the earth.Wind turbines convert the energy in wind to electricity by rotating propeller-like blades around a rotor. The rotor turns the drive shaft, which turns an electric generator. Three key factors affect the amount of energy produced by a turbine are as:

i Wind speed: The amount of energy in the wind varies with the wind speed means, if the wind speed doubles, there is eight times more energy in the wind. Small changes in wind speed have a large impact on the amount of power available in the wind.

ii Air density: The more dense the air, the more energy received by the turbine. Air density varies with elevation and temperature. Air is less dense at higher elevations than at sea level, and warm air is less dense than cold air.

iii Swept area: The larger the swept area (the size of the area through which the rotor spins), the more power the turbine can capture from the wind. The amount of power that can be produced from wind, depends on the size of the turbine and the length of its blades. The output is proportional to the dimensions of the rotor and to the cube of the wind speed. When wind speed doubles, wind power potential increases by a factor of eight.

Production from Water:

Power derived from water is known as hydropower or water power. It is the power derived from the energy of falling water or fast running water. Since ancient times, hydropower has been used as a renewable energy source for irrigation. In the late

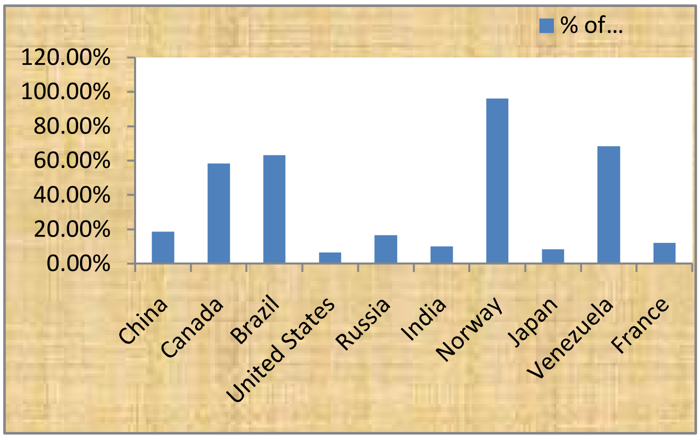

Figure-4: Ten of the largest hydroelectric producers at global level

19th century, hydropower became a source for generating electricity. The first commercial hydroelectric power plant was built at Niagara Falls in 1879. In 1881, street lamps in the city of Niagara Falls were powered by hydropower. Hydropower is based on water cycle:

The solar energy heats water on the surface of river sand causes the water to evaporate. Now water vapor condenses into clouds and falls in the form of rain and snow. Finally rain and snow collects in streams and rivers, which flow into oceans and lakes, where it evaporates and begins the water cycle again. Some countries generating the hydroelectric at larger scale are shown in figure as follows:

Production from Geothermal:

The thermal energy generated and stored in the earth is called geothermal energy. The geothermal energy of the Earth's crust originates from the original formation of the planet and from radioactive decay of materials. The geothermal gradient, which is the difference in temperature between the core of the planet and its surface, drives a continuous conduction of thermal energy in the form of heat from the core to the surface.

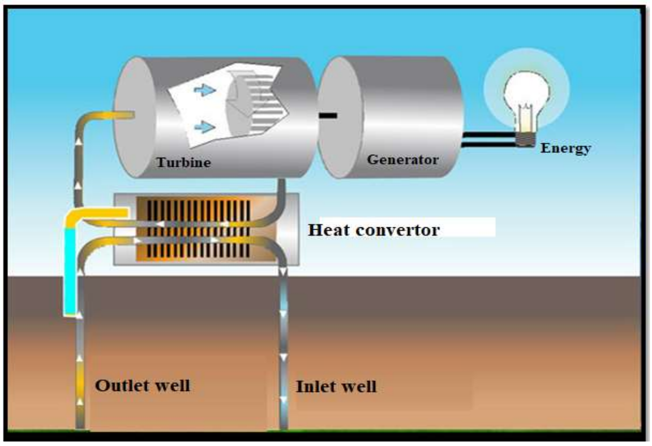

Figure:5- The Geothermal Energy production

To produce geothermal-generated electricity sometimes a mile (1.6 kilometers) deep wells are drilled into underground reservoirs to tap steam and very hot water that drive turbines linked to electricity generators. The first geothermally generated electricity was produced in Larderello, Italy, in 1904. The production of Geothermal Energy is shown in figure 5.

There are three types of geothermal power plants through power generation is going on in different countries:

(i) Dry steam Plant: It is the oldest geothermal technology, takes steam out of fractures in the ground and uses it to directly drive a turbine.

(ii) Flash Plant: Flash plants uses, high-pressure hot water into cooler. The steam that results from this process is used to drive the turbine.

(iii) Binary Plant: Binary plants is commonly used plant now a days. In it the hot water is passed by a secondary fluid with a much lower boiling point than water. This causes the secondary fluid to turn to vapor, which then drives a turbine. Most geothermal power plants in the future will be binary plants.

Geothermal energy is produced in over 20 countries. The United States is the world's largest producer, and the largest geothermal development in the world is The Geysers north of San Francisco in California. In Iceland, many of the buildings and even swimming pools are heated with geothermal hot water. Iceland has at least 25 active volcanoes and many hot springs and geysers. The production of energy through binary geothermal power plant is shown in figure.

(F) Production from Photo volt: The conversion of light into electricity using semiconducting materials is known as the photovoltaic effect.

A photovoltaic system employs solar panels, each comprising a number of solar cells, which generate electrical power. PV installations may be ground-mounted, rooftop mounted or wall mounted. The mount may be fixed, or use a solar tracker to follow the sun across the sky.

Solar PV has specific advantages as an energy source: once installed, its operation generates no pollution and no greenhouse gas emissions, it shows simple scalability in respect of power needs and silicon has large availability in the Earth's crust.

Production from Nucleus: Nuclear power can be obtained from nuclear fission, nuclear decay and nuclear fusion reactions. Presently, the vast majority of electricity from nuclear power is produced by nuclear fission of uranium and plutonium.

In it when a neutron hits the nucleus of a uranium-235 or plutonium atom, it can split the nucleus into two smaller nuclei. The reaction is called nuclear fission. The fission reaction releases energy and neutrons. The released neutrons can hit other uranium or plutonium nuclei, causing new fission reactions, which release more energy and more neutrons. This is called a chain reaction. The reaction rate is controlled by control rods that absorb excess neutrons.

Civilian nuclear power supplied 2,488 **terawatt hours (TWh)** of electricity in 2017, equivalent to about 10% of global electricity generation. As of April 2018, there are 449 civilian fission reactors in the world, with a combined electrical capacity of 394 **giga watt(GW).** As of 2018, there are 58 power reactors under construction and 154 reactors planned, with a combined capacity of 63 GW and 157 GW, respectively. As of January 2019, 337 more reactors were proposed.

A fission nuclear power plant is generally composed of a nuclear reactor, in which the nuclear reactions generating heat take place; a cooling system, which removes the heat from inside the reactor; a steam turbine, which transforms the heat in mechanical energy; an electric generator, which transform the mechanical energy into electrical energy.

Electricity was generated for the first time by a nuclear reactor on December 20, 1951, at the EBR-I experimental station near Arco, Idaho, which initially produced about 100 kW.

2.5. Energy Consumption from Non conventional energy sources

World final energy consumption refers to the fraction of the world's primary energy that is used in its final form by humanity. The consumption of energy from non renewable sources in different forms is as follows:

(A) Consumption of coal:

Consumption of fossil fuels varies by region and by country. The biggest consumers are the United States, China, and the

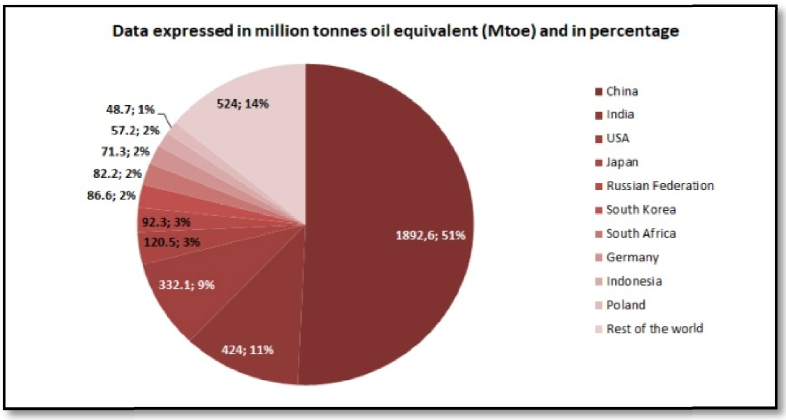

Figure: 6- Top ten coal consuming countries
(Data source: BP Statistical Review of World Energy, 2018)

European Union, accounting for more than half of all fossil fuel consumption. Coal, which is not easily, transported long distances, accounts for a large percentage of consumption where it is locally available.

Coal is mainly consumed for electricity production, with two-thirds of world consumption going to electricity production.

Worldwide, coal consumption for electricity generation is almost growing at the same rate as the electricity consumption was 2.8% per year versus 3% per year between 2000 and 2017.

The major coal-producing countries such as Indonesia (58% of electricity produced from coal), Turkey 33%, and India 75%. India is the second largest coal producer in the world after China with significant coal reserves.

Other countries are also have the utility of coal to produce their electricity: Malaysia 45%, Chile 37%, South Korea 46%, and Japan 33%.These countries depends on coal for several reasons: in addition to often being a cheaper source of electricity, coal limits their dependence on oil- and gas-producing countries. Due to the lack of domestic fossil fuel resources, Japan is one of the largest oil, natural gas and coal-importing country. 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. Most of the other 82% was used for heat and transportation. (**World Energy report, 2018)**

The above mentioned figure shows the top 10 coal consuming countries and coal consumption in the rest of the world in 2017. Global coal consumption amounted to 3731.5 Mtoe; China is the main coal consumer (1892.6 Mtoe, 51%), followed by India (424 Mtoe, 11%) and the USA (332.1 Mtoe, 9%). Global coal consumption rose by 1%, (25 mtoe), with India (4.8%, 18 Mtoe) recording the fastest growth, as demand both inside and outside of the power sector increased. Interestingly, after three years of successive declines, China's coal consumption (0.5%, 4 Mtoe) also ticked-up. This is despite the substantial coal-to-gas switching in the industrial and residential sector, as increases in power demand in China sucked in additional coal as the balancing fuel. (**World Energy report, 2018)**

(B) Consumption of Crude Oil:

US is the world's biggest oil-consuming country, consumed 19.88 million barrels of oil per day (mbd) in 2017, which accounted for nearly 20.2 percent of the world's total oil consumption per day. China consumed oil 12.79mbd in 2017, accounting for about 13 percent of the world's total oil consumption making it the second biggest oil consumer after the United States. (**World Energy report, 2018)**

India consuming 4.69 million barrels of oil per day; Japan, consuming 3.98 million barrels of oil per day; and Saudi Arabia consuming 3.91 million barrels of oil per day. Together, these countries gobble up more than 45 million barrels every day.

Chinese demand has increased by almost 5.0 million BPD over the past decade, from 7.8mbd in 2017 to 12.85mbd in 2017- by far the most of any country. Similarly, oil demand in India has increased by almost 2.0 million BPD over the past decade, from 2.94mbd in 2007 to 4.69 million barrels of oil per day (mbd) in 2017, shown in table 3 as: (**World Energy report, 2018)**

Table:3- Countries and their share of total world oil consumption (Thousand Barrels per Day) (source: World Energy report, 2018))

S.No.	Country	Consumption (Thousand Barrels)	Global Share in %
1	US	19880	20.2
2	China	12799	13.0
3	India	4690	4.8
4	Japan	3988	4.1
5	Saudi Arabia	3918	4.0
6	Russia	3224	3.3
7	Brazil	3017	3.1
8	South Korea	2796	2.8
9	Germany	2447	2.5
10	Canada	2428	2.5

(C) Natural Gas Consumption:

We know that past years were the bumper years for the consumption of natural gas, with 3.0%, The growth in consumption was led by Asia, with particularly strong growth in China 15.1%, , supported by increases in the Middle East as Iran 6.8%, and Europe. The growth in consumption was more than matched by increasing production, particularly in Russia 8.2%, , supported by Iraq 10.5%, , Australia 18%, and China 8.5%. (**World Energy report, 2018)**

This is well known fact that global gas consumption last year was the surge in Chinese gas demand, where consumption increased by over 15%, accounting for around a third of the global increase in gas consumption. Chinese gas demand looks set to continue to increase strongly this year.

The other central factor supporting the strength of global gas markets last year was the continued expansion of liquefied natural gas (LNG), which increased by over 10% in past years.

(D) Consumption of Kerosene:

A light petroleum distillate that is used in space heaters, cook stoves, and water heaters and is suitable for use as a light source when burned in wick-fed lamps. Kerosene has a maximum distillation temperature of 400^{0}F at the 10-percent recovery point, a final boiling point of 572^{0}F, and a minimum flash point of 100 ^{0}F. (**World Energy report, 2018)**

Table-4: The consumption of kerosene at top 10 countries.

Rank	Country	Consumption (Thousand Barrels per Day)
1	Japan	345
2	India	167
3	Iran	98
4	United Kingdom	72
5	Korea	63
6	Iraq	54
7	Nigeria	56
8	China	41
9	Indonesia	24
10	Ireland	16

2.6: Energy Consumption from conventional energy sources

It is as follows:

(A) Solar energy and P.V. energy Consumption: Recently it came in origin that solar energy can replace other energy sources as per the demand of electricity. Here we have some countries in which the consumption of solar energy and P.V. energy is good in demand and use. These countries are as follows:

1-China: China is leading the world in solar P.V. generation, with the total installed capacity more than 100 GW. China is the world's largest market for both solar thermal energy and photovoltaics and in the last years more than half of the total P.V. additions came from China.

2-Japan: Solar power in this country has been expanding since the late 1990s.Cumulative installed PV capacity reached over 50 GW with around 8 GW installed in the year 2017. This country is a leading manufacturer of solar panels and is in the top 4 ranking for countries with the most solar P.V. installed.

3-Germany: Germany is among the top 4 ranking countries which installed photovoltaic solar capacity and number one regarding per capita installation of PV.

4-USA: United States had over 50 GW of installed photovoltaic capacity. In the twelve months through May 2018. Installations have been growing rapidly in recent years as costs have declined with the United States. (**World Energy report, 2018)**

5-Italy: Italy added around 400 MW of solar PV capacity in the year 2017 reaching a total installed PV capacity of around 19.7 GW.

6-UK: It is known that at the end of 2011, there were 230,000 solar power projects in UK with a total installed generating capacity of 750 **mega watt (MW**). Solar power use has increased very rapidly in the last few years in UK. (**World Energy report, 2018)**

7-India: In the year 2017 alone India added a record around 9 MW of solar power with another 9,627 MW of solar projects under development India launched its National Solar Mission in 2010 under the National Action Plan on Climate Change, with plans to generate 20 giga watt(GW) by 2022. (**World Energy report, 2018)**

8-France: Solar power in France including overseas territories reached an installed capacity figure of around 7 MW by year end 2016.

9-Australia: Australia had over 10 megawatts (MW) of installed photovoltaic (PV) solar power by September 2018.The largest solar power station in Australia is the 220 megawatts (MW) Bungala solar plant. (**World Energy report, 2018)**

10-Spain: Spain was an early adopter in the development of solar energy industry since it is one of the countries of Europe with more hours of sunshine. Total solar power in Spain reached around 7 GW in past years.

Photovoltic energy is most important renewable energy source in terms of globally installed capacity. In past years more than 100 GW of solar photovoltaic (PV) power was installed in the world, an amount capable of producing at least 110 TWh of electricity every year.

(B) Biomass energy Consumption:

Biomass is any organic matter, i.e. biological material, available on a renewable basis. Includes feedstock derived from animals or plants, such as wood and agricultural crops, and organic waste from municipal and industrial sources.

The energy generated from the conversion of solid, liquid and gaseous products derived from biomass is called bio Energy.

(C) Wind energy Consumption:

As per the demand of electricity in the world, the renewable energy is used as wind energy. Technology has evolved over the last five years to maximize electricity produced per megawatt capacity installed to unlock more sites with lower wind speeds. Wind turbines have become bigger with taller hub heights, and larger rotor diameters.

Cumulative grid-connected wind capacity reached 515 GW in past years and wind power accounted for almost 4% of global electricity generation.

Wind energy is expected to grow by 323 GW in the next five years and reach almost 839 GW by 2023 in the main case of the IEA's Renewable 2018 forecast. China leads this growth followed the United States, Europe and India. As a result, the wind electricity generation would increase by nearly 65% globally over 2018-23.

Wind energy is used by deploying turbines in the sea, takes advantage of better wind resources than at land-based sites. Therefore, new turbines are able to achieve significantly more full-load hours ranging from 40-55% depending on resource availability.

In past years global wind energy generation reached an estimated 55 TWh. By 2023, global wind energy uses will expected to reach 52 GW by 2023. Deployment will be led by the European Union and China enhanced the policies and faster deployment of projects for the same.

(D) Water energy Consumption:

Hydropower is the most flexible and consistent of the renewable energy resources, capable of meeting base load electricity requirements as well as, with pumped storage technology. There are many opportunities for hydropower development throughout the world.

By generating electricity from hydropower instead of coal, in 2017 the world prevented approximately 4 billion tonnes of greenhouse gases and avoided a 10 per cent rise in global emissions from fossil fuels and industry. It also avoided 148 million tonnes of air polluting particulates, 62 million tonnes of sulphur dioxide, and 8 million tonnes of nitrogen oxide from being emitted. There are three types of hydropower stations: 'run of river', where the electricity is generated through the flow of a river'; 'reservoir', where power is generated through the release of stored water; and 'pumped storage', where stored water is recycled by pumping it back up to a higher reservoir in order to be released again. At the end of 2015, the leading hydropower generating countries were China, the US, Brazil, Canada, India and Russia.

(E) Geothermal energy Consumption:

The consumption of geothermal energy is increasing day by day, world geothermal heat consumption direct & storage reached in 2014 563 PJs. Roughly 40% represents direct use as the balance comprises energy used from heat pumps. China dominates heat usage with over half of the world's consumption. Europe is the second largest user with 30% of world consumption. Direct heat use is geographically concentrated in regions above 35^{o} latitude due to heating requirements during winter.

(F) Nuclear Energy consumption:

The consumption of nuclear energy will certainly change during the next 10 to 20 years because several countries decided not to replace retired nuclear power plants anymore and to phase-out nuclear energy. In the European Union, 17 out of the 27 member countries do either have no nuclear power plants or have already decided to sooner or later phase out this technology among them. These countries are Sweden, Spain, Italy, Belgium, Austria and Germany. Switzerland is also quite unlikely to rebuild nuclear power plants in future.

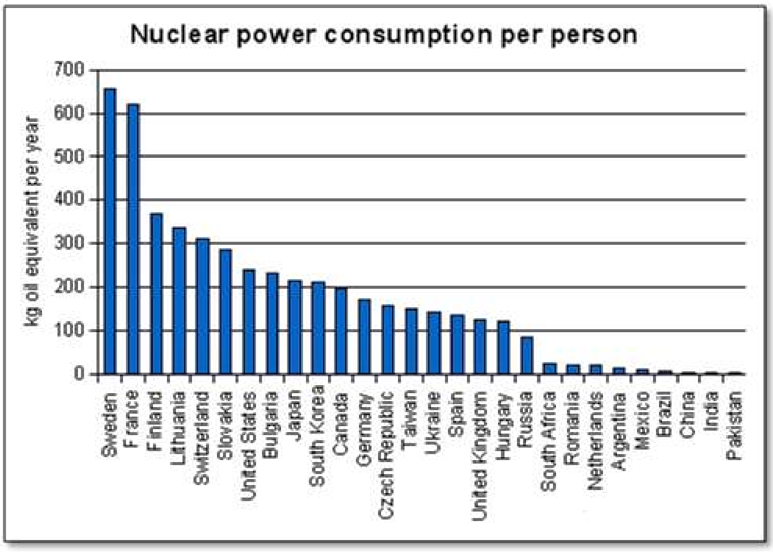

Figure:7- The use of Nuclear power consumption per capita by different countries.

The above figure 7 shows the nuclear power consumption per capita by country for the past years. The raw data was taken from bp.com and converted in kg oil equivalents.

2.7 Summary

In this unit various aspects of production and consumption of energy are discussed. So far you have learnt:

The meaning of "Non- renewable Sources" is not to re-occur means when consumed once then not reused by human society.

The meaning of "Renewable Sources" is to be use again and again by human society.

How are total levels of production and consumption distributed across the world's regions?

The concepts for the purpose of generalizing to extend is to verify facts, whether that knowledge helps to understand of theory.

The common types of non renewable sources of energy are fossils fuels and of renewable sources of energy are wind, water, solar etc.

Consumption across the rest of the world has been increasing, most dramatically in the Asia Pacific where the total production and consumption increased in past years.

The general objectives of this unit are to understand the global conditions of demand and supply of energy along with the relationship with each other.

The Middle East, Latin America and Africa account for around seven, five and three percent, respectively.

We have seen back in 1800 then we found that nearly all of the world's energy was produced from traditional biomass as burning wood and other organic matter. The world predominantly UK was using a small amount of coal- only around two percent.

By the mid-20th century, the energy mix had diversified significantly; coal overtook traditional biofuels and oil was up to around 20 percent. By 1960 the world had moved into nuclear electricity production. Finally, today's renewables as modern biofuels, wind, and solar are relatively new, not appearing until the 1980-90s. Other renewable sources, such as geothermal and marine technologies, have not been included because levels of production are so small.

In 2015, the world consumed 146,000 terawatt-hours (TWh) of energy- more than 25 times more than in 1800. But it is often today's energy utility, rather than levels of consumption that people find surprising. While some may have the impression that renewables

account for a large share of global energy consumption, their total contribution in fact remains small.

Terminal Questions

Q.1.) Fill in the blanks

Before millions of years the .... residue was converted to .... by a pair of complex chemical processes known as diagenesis and catagenesis. .... occurs ...., and involves both .... activity and chemical reactions as dehydration, ..., cyclization, and .... whereas .... occurs between .... It involves catalytic cracking, ... and hydrogen disproportionation. So in production of kerosene first step is to collect the crude oil by .... which is separated into its components before turning into kerosene. Distilled long .... is used for this process and the .... occurs. After extraction refined .... stored in tanks for use.

Q.2.) Define energy scenario at different levels.

Q.3.) Explain in brief the Energy Production from Non-renewable energy sources.

Q.4.) What are the renewable energy sources used for the Energy Production.

Q.5.) How will you define the Energy Consumption?

Q.6.) Define the production of coal at global level.

Q.7.) Explain the Operation of Natural gas power plants.

Q.8.) Describe the Countries and their share of total world oil consumption**.**

Q.9.) Fill in the blanks

By generating ……….. from ………… instead of coal, in 2017 the world prevented approximately 4 billion tonnes of ………… gases and avoided a 10 per cent rise in ………. emissions from ………… fuels and industry. It also avoided 148 million tonnes of air …………… particulates, 62 million tonnes of …………., and 8 million tonnes of …………..from being emitted. There are three types of hydropower stations: …………., where the electricity is generated through the flow of a river'; 'reservoir', where power is generated through the release of stored water; and …………., where stored water is recycled by pumping it back up to a higher reservoir in order to be ………… again. At the end of 2015, the leading hydropower generating countries were …………, the US, Brazil, Canada, ………. and Russia.

Q.10.) Write down the full forms of the given as:

(a) Bt

(b) mb

(c) EIA

(d) PV

(e) TWh

(f) GW

(g) LNG

(h) MW

Answers

Q.1.) organic, petroleum, Diagenesis, below 122^0 F, microbial, condensation, polymerization, catagenesis, 122^0F and 392^0F, decarboxylation, drilling, column, purification , kerosene .

Q.2.) Pls. refer 2.2

Q.3.) Pls. refer 2.3

Q.4.) Pls. refer 2.4

Q.5.) Pls. refer 2.5

Q.6.) Pls. refer 2.3 part A

Q.7.) Pls. refer 2.3, part C

Q.8.) Pls. refer 2.5 part B

Q.9.) electricity, hydropower, greenhouse, global, fossil, polluting, sulphur dioxide, nitrogen oxide, run of river, pumped storage, released, China, India.

Q.10.)

(a) Billion tonnes

(b) million barrels

(c) Energy Information Administration

(d) PhotoVoltaic

(e) TeraWatt hours

(f) Giga Watt

(g) Liquefied Natural Gas

(h) Mega Watt

Reference

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UNIT-3: GLOBAL AND NATIONAL STATUS

Unit Structure

3.0 Learning Objectives

- In this unit you will be able to understand:
- The global status based on energy and different types of energy strategies for a sustainable world.
- Energy demand in different countries along with the role of state Governments.
- Scenarios as a tool which can help civilization to better understand what the future might look like.
- Evolution of international governance structures and a significant impact on economic and energy policies.

- Role of new technologies with emerging demand of energy and role of National and International agencies to govern the energy sector.
- Our National Status and key objectives for national energy policies.
- Role of State Governments in development of renewable energy as both local infrastructure and purchase support and
- Vision 2040 of India in energy sector.

3.1. Introduction

We know that the human civilization is growing day by day. The demand and supply of energy is also increasing, for the same the countries are using latest technologies to produce conventional and non conventional energies to fulfill the demand of energy.

Global energy consumption in 2018 increased at nearly twice the average rate of growth since 2010, driven by global economy and higher heating and cooling needs in some parts of the world. Demand for all fuels increased, led by natural gas, even as solar and wind posted double digit growth. Higher electricity demand was responsible for over half of the growth in energy needs. The biggest requirement came from natural gas, which emerged as the fuel of choice last year, accounting for nearly 45% of the increase in total energy demand. Demand for all fuels rose, with fossil fuels meeting nearly 70% of the growth for the second year running. World is a rapidly growing economy which needs energy to meet its growth objectives in a sustainable manner. The global economy faces significant challenges in terms of meeting its energy needs in the coming decade. The increasing energy requirements coupled with a slower than expected increase in domestic fuel production has meant that the extent of imports in energy is growing rapidly.

In India, a population of over 1.21 billion as per 2011 census with 70% of total population living in rural areas. Out of these 1210 million people the 396 million does not have access to electricity and 592 million people still use firewood for cooking. Majority of these people reside in rural areas and are still dependent on non-commercial energy sources, such as fuel wood, crop residue, and animal waste for their energy needs. Furthermore, about 80% of the population - which includes 28% of urban inhabitants - still relies on combustion of biomass fuels for cooking activities.

Although India is dependent on commercial fuels, a sizeable quantum of energy requirements as 40% of total energy requirement, especially in the rural household sector, is met by non-commercial energy sources. Building new refineries, coal and gas fired power stations. Reducing cross subsidies on oil products and electricity tariffs. Investment legislation to attract foreign investments. Streamlining approval process for attracting private sector participation in power generation, transmission and distribution.

3.2. Global Status based on Energy

We know that energy consumption in developing countries is only one-tenth of that in the developed countries. Share of non-hydro renewable in power generation increased from 2.5% to 8.6%. World electricity demand increase at a rate of 2.5%. ′Natural gas has been the energy source with highest rates of growth in recent years. Consumption of gas has increased from 14.4% to 15.6%. Demand of oil rise from 85 million barrel (mb) per day to 106 mb. Developed countries consume 43 million barrels daily on an average while developing countries consume only 22 million barrels. Oil is the most important and abundant source of energy in the world. World primary energy demand increase by 1.6% per year on an average. (**Global Energy Economics, 2019)**

3.2.1. Energy Strategies for a Sustainable World

The whole world uses three types of strategies to meet out the challenges arise in energy sectors as:

i) Immediate term strategy: It is the optimum utilization of existing assets. Efficiency in production system and reduction in distribution losses. In it the countries promoting the R and D, transfer and use of technologies for environmentally sound energy systems.

ii) Medium-term strategy: It demands management systems through conservation of energy, structural changes in economy, recycling a shift to less energy and transport shift to renewable sources of energy.

iii) Long term strategy: It is the efficient generation of energy resources and work for efficient production of coal, oil and natural gas. In it the countries improving energy efficiency in accordance with national, socio-economic and environmental priorities. It promotes the energy efficiency and emission standards. It also conducts programs for adopting energy efficient technologies in large industries.

3.3 World energy demand

The energy demand will increase before 2030 by using new technologies and more powerful energy policies. Since 1970, demand for energy has more than doubled. New technologies to 2060 will keep energy demand growth moderate relative to historical trends, and will help to enable industrialized economies to transition more quickly. Efficiency gains will be made through the deployment of digital technologies, smart buildings, smart homes, offices and smart cities. Advanced manufacturing, automation, telecommuting, and other technologies also will disrupt traditional energy systems. As a result, final energy consumption to 2060 grows 22%.(**Sharma, 2018 Text Book)**

a) Demand for Electricity: The demand of electricity will double to 2060 and for meeting this demand with cleaner energy sources the world will require substantial infrastructure investments and systems integration to deliver benefits to all consumers. Technology-enabled urban lifestyles demand more electricity. The growth of the middle class, rising incomes, and more electricity-enabled appliances and machines contribute to electricity demand doubling to 2060. Electricity reaches 29% of final energy consumption. New cleaner generation is needed to meet climate targets and utility business models. More stringent regulatory requirements for a low-carbon future will force companies everywhere to make significant changes in their business models to get clean environment.

b)World Energy Council: According to World Energy Council solar and wind energy will continue at huge rate and create both new opportunities and challenges for energy systems. Growth in non-fossil energy sources will dominate electricity generation to 2060, driven by solar and wind capabilities. Solar and wind energy account for only 4% of power generation in 2014, but by 2060 it will account for 20% to 39% of power generation. Strong policy supported by hydro and nuclear capacity additions will allow intermittent renewable to reach 39% of electricity generation by 2060. Large-scale pumped hydro and compressed air storage, battery innovation, and grid integration provide dependable capacity to balance intermittency. For solar and wind resources, the largest additions will be seen in China, India, Europe, and North America. (**Sharma, 2018)**

c) Demand for Coal and Crude oil: It has the potential to take the world from "Stranded Assets" to "Stranded Resources". Fossil fuel share of primary energy has shifted just 5% in the last 45 years from 86% in 1970 to 81% in 2014. To 2060, the momentum of new technologies and renewable energy generation results in the diversification of primary energy. Fossil fuel share of primary energy will fall to 70% by 2060. (**Sharma, 2018)**

d) Transitioning Global Transport: It forms one of the hardest obstacles to overcome in an effort to decarbonise future energy systems. The diversification of transport fuels drives disruptive change that helps to enable substantial reductions in the energy and carbon intensity of transport. Advances in second and later third generation biofuels will cover up to 10% of total transport fuel in 2060. Hybrid petroleum vehicles reflect another 24% to 31% share in future. (**Global Energy Economics, 2019)**

3.3.1. Energy Policies and the Role of the State

In most countries, national energy policies have shaped major decisions on energy and still do so today. These policies reflect energy resource and energy needs. The role of the state in running energy enterprises has evolved in many directions across energy sectors. For example, in 1970 virtually all electricity companies were state run, but this changed in the 1990s as many governments pursued liberalization. However, the private oil companies that dominated the international oil industry in 1970 have been progressively eclipsed by the state-run national oil companies (NOCs). In recent years we have seen the rise of smaller independent operators that offer a new model for exploration, production and midstream assets on state levels. The role of private versus state-owned enterprises in energy developments will continue to shift over the next 45 years. Addressing this affordable energy and environmental sustainability of providing energy the state governments require decision makers in government and business to strike a delicate balance between individual country and world energy goals.

3.4. Role of World Energy Scenarios

The World Energy Council aims to provide a wide range of the current status and future of the world's energy industry by its four flagship studies. These are:

- To monitor, covering current issues identified by energy executives.
- World Energy Trilemma Index, examining country energy policy performance and trade-offs.
- World Energy Resources, highlighting developments in energy resources and technologies.

The World Energy Scenarios, providing inputs based on views of possible futures for the energy industry with partners to consider potential implications of future events. They give strategy developers a common language for thinking and talking about current and future events.

What are Scenarios? Scenarios use rigorous research and analysis to map out possible contrasting future worlds. Scenarios are a tool which can help us to better understand what the future might look like and the likely challenges of living in it. Oil prices are assumed differently in the three scenarios. A rising price for oil is assumed for all except the 450 Scenario. Gas prices show a significant upward trend in all regions, especially for the New Policies and the Current Policies Scenario. The rise of natural gas import prices is lower than in the other scenarios and between 2030 and 2035 stagnation and decrease of prices is assumed respectively.

3.5. International Governance

The evolution of international governance structures and the nature of state rivalry have a significant impact on economic and energy policies and the pattern of energy trade. The current international governance structure was established in 1945 with the founding of the United Nations. The UN's charter enshrined the veto rights of the five permanent members of the Security Council as China, France, Russia, the United Kingdom, and the United States. Economic institutions were shaped in the 1970 and the leaders of the G7 have met since 1977 and in 2008, meetings began among the leaders of the G20 also. The G20, leaders continue to search for a representative structure that can effectively reflect the new economic and political realities of a 'globalising world'.

3.6. New technologies

New technologies, including the full diffusion of information, sensing, communication, automation and health. These techonologies have the potential to reshape economic and social options. For example, fully driverless Electric Vehicles (EVs) are fast becoming a reality. The combinatorial effect of battery technology, GPS, machine learning and analytics have created the right environment to accelerate what was previously seen as niche development or a longer-term change. As these technologies mature, combine and are deployed across the economy, in the broadest sense we will see major changes in the energy industry, including:

* Smart cities, in a world that is 70% urbanized by 2060.

*Automation, artificial intelligence and robotics will play an important role.

* Workforce of the future and digital productivity.

* Energy efficiency and demand side behavior.

* Automated zero carbon mass transit innovation.

* Wind and solar integrated grid/storage.

* Electric vehicles (EV) the dominant technologies.

Energy prices have a high influence on energy trends. They affect the amount of fuel the consumer of energy services wants to consume and if a greater effort is taken to enhance energy efficiency of technologies.

3.7. World Energy Resources

Energy is the primary 'fuel' for human civilization and economic development, but energy and energy-related activities also have significant impact on environment. Therefore, it is important for policy-makers to have access to reliable and accurate data in a user-friendly format. The energy sector has long lead times and therefore any long-term strategy should be based on sound information and data. Detailed resource data, selected cost data and technology overview in the main World Energy Resources report provide an excellent foundation for assessing different energy options. The World Energy Council (WEC) has for decades been a pioneer in the field of energy resources and work of WEC is divided into thirteen resource-specific work groups, called Knowledge Networks. These Knowledge Networks provide updated data for the website and publications, as well as working on timely deep-dives with a resource focus.

The latest World Energy Resources 2016 report was published at the World Energy Congress in Istanbul. The report featured updated data and analysis on each of thirteen topics with introductory commentaries written by expert persons.

“The World Energy Resources (WER) is a unique World Energy Council study covering 13 key energy resources as:

- The past 15 years have seen the change in the utilization of energy.
- Unexpected tremendous growth in the renewable market.
- Growth of unconventional resources.
- Improvements in technology evolution for all the resources.
- Decrease in energy prices.
- Decoupling of economic growth and Green House Gases (GHG) emissions.
- More diversified energy mix achieved.
- Growth in community ownership.
- General trend of smaller generation across technologies and resources.
- Energy sources are moving closer to users.
- Costs are coming down for most energy resources and technologies.
- Subsidies for clean energy as well as fossil fuels are depleting in some nations.
- Competitive auctions, changing the development process and risk profile of individual projects.

3.8. Role of International Agencies

At global level we have various international agencies for making different reports to make an outlook on the status of energy. These reports generate a status on the production and consumption of energy based on demand and supply concept. The agencies/ ministries/ regional associations/ councils and regulators are located or acting in different countries as mentioned in tables 1 and 2.

Table-1: Some electric utility regulators in Asia and North America:

South Asia	
India	**Central Electricity Regulatory Commission (CERC), Atomic Energy Regulatory Board (AERB)**
Malaysia	Energy Commission of Malaysia
Nepal	Nepal Electricity Authority (NEA)
Oman	Authority for Electricity Regulation (AER)
China	State Electricity Regulatory Commission (SERC) China Atomic Energy Authority (CAEA)
Philippines	Energy Regulatory Commission (ERC)
Singapore	Energy Market Authority (EMA)
Sri Lanka	Public Utilities Commission of Sri Lanka (PUCSL)
Thailand	Energy Regulatory Commission (ERC)
North America	
Canada	National Energy Board (NEB), Canadian Nuclear Safety Commission (CNSC)
United States	Federal Energy Regulatory Commission (FERC), Nuclear Regulatory Commission (NRC)

Table-2: Some of the regulatory authority/ commission

Albania	Energy Regulatory Authority
Azerbaijan	Tariff (Price) Council of the Republic of Azerbaijan
Bulgaria	State Energy and Water Regulatory Commission
Egypt	Egyptian Electric Utility and Consumer Protection Regulatory Agency
Georgia	Georgian National Energy and Water Supply Regulatory Commission
Hungary	Hungarian Energy Office
Kazakhstan	Agency of the Republic of Kazakhstan for Regulation of Natural Monopolies
Mongolia	Energy Regulatory Authority
Poland	Energy Regulatory Office
Romania	Romanian Energy Regulatory Authority
Russia	Federal Tariff Service
Serbia	Energy Agency of the Republic of Serbia
Slovakia	Regulatory Office for Network Industries
Turkey	Energy Market Regulatory Authority

Ukraine	National Electricity Regulatory Commission of Ukraine

- **Energy Regulators Regional Associations:**

The Energy Regulators Regional Association (ERRA) is a voluntary organization of independent energy regulatory bodies acting in Central European and Eurasian region, with Affiliates from Asia the Middle East and the US. ERRA began as a cooperative exchange among energy regulatory bodies to improve national energy regulation in member countries.

- **Council of European Energy Regulators:**

  The Council of European Energy Regulators is a not-for-profit organization in which Europe's national regulators of electricity and gas voluntarily cooperate to protect consumers' interests. The council facilitates the creation of a single, competitive and sustainable internal market for gas and electricity in Europe. **CEER** currently has **29 members**.

Some other ministries and agencies working at global level are as follows:

- **Austria: Federal Ministry of Digital and Economic Affairs:**

  The Federal Ministry of Digital and Economic Affairs develops the policies and regulations overseeing business services to encourage innovation and investment in the country.

- **Bulgaria: Ministry of Economy**

  The Republic of Bulgaria Ministry of Economy is responsible for the implementation and regulation of government policies as it impacts the business services industries.

- **Denmark: Danish Ministry of Energy, Utilities and Climate:**

  The Danish Ministry of Energy, Utilities and Climate aims to prevent climate change and addresses energy issues, meteorology, and buildings. It also conducts national geological surveys in Denmark and Greenland.

- **Germany: Federal Ministry of Economic Affairs and Energy**:

The Federal Ministry of Economic Affairs and Energy is responsible for policy and regulatory development that impacts the business services, energy, technology, and hospitality and travel industries. This site contains information on the various trade agencies Germany is involved with, as well as statistical data and policies.

- **Japan Atomic Energy Agency (JAEA) :**

  The Japan Atomic Energy Agency (JAEA) is responsible for the regulation and oversight of the atomic energy industry in Japan.

- **Netherlands: Ministry of Economic Affairs:**

  The Ministry of Economic Affairs is in charge of policy development to create a sustainable, competitive business environment in the Netherlands. Specific focus is placed on agriculture and energy, as well on a balance between ecology and economy.

- **Norway: Ministry of Petroleum and Energy:**

  The Ministry of Petroleum and Energy is responsible for policy development and regulation as it applies to the Norwegian energy industry.

- **Sweden: Ministry of the Environment and Energy**:

  The Ministry of the Environment and Energy in Sweden is responsible for promoting sustainable development in the country by implementing environmental legislation and policies.

- **Turkey: Turkish Atomic Energy Authority:**

  The Turkish Atomic Energy Authority is responsible for the oversight and regulation of atomic energy use within Turkey. This site contains a listing of all international agreements.

- **United States: Department of Energy :**

  The United States Department of Energy regulates and oversees the energy industry to ensure that both energy and environmental needs are met. The site contains sections about public services provided by the department, science and innovation, and saving energy.

3.9. National Status

Being a tropical country, India receives solar insulation of the order of 1650-2100 kw/m^2/year for nearly 250-300 days so daily solar energy incidence varies between 5-7 kwh/m^2 in different parts of country. The total solar energy received by India is 19 trillion kwh per day which is about 2.2 million tons of coal to 1.5 million tons of oil equivalent. There is average wind density of 35 kwh/ m^2/ day at number of places at India. India has an over 6000 km long coastline and so tremendous prospects of harnessing energy from ocean too. (**Ministry of New and Renewable Resources, GOI)**

Solar, wind, hydropower, wave energy, tidal power, ocean thermal energy are renewable energies whereas fossil fuels constitute non-renewable energy. India is well situated for exploiting renewable energy sources.

The different programmes to meet out the demand at national levels under Indian government/ NGOs and different agencies are going to make the country more progressive. The programmes under different categories are as follows:

(1) National (Government) Programmes for energy:

i) Rajiv Gandhi Grameen Vidyutikaran Yojana (RGGVY):

This scheme was launched by the (Ministry of Power) MoP in 2005 to increase the pace of rural electrification under the "Power for all by 2012" initiative. The following points are focused in this project are as:

* Village Electrification Infrastructure (VEI) with provision of minimum of one distribution transformer in each village or habitation.

* Decentralized Distributed Generation (DDG) systems based on conventional sources or renewable energy where grid supply is not feasible or cost-effective.Final consumers would need to pay connection fees; however, for households below the poverty line ("BPL Households"), no connection fee would be charged.
RGGVY aims to electrify 125,000 villages and connect the entire 23.4 million "below poverty line" households with free connection.

ii)Remote Village Electrification (RVE) Programme: The Remote Village Electrification (RVE) programme of the Ministry of new and renewable energy (MNRE) supplements the efforts of MoP by electrifying un-electrified remote villages and hamlets where :

(i) grid connectivity is not feasible or not economical, and

(ii) where DDG projects underRGGVY are not implemented. REC decides whether villages/hamlets will be covered under RGGVY or RVE. The RVE programme is implemented in the states by state nodal agencies, which receive 90% capital subsidy from the MNRE. A remote village or remote hamlet will be considered electrified if at least 10% of the households are provided with lighting facility. The RVE is technology neutral, but in 80-85 % electricity is provided through solar PV systems.

(iii) Village Energy Security Test Projects (VESP), since 2004: The aim of the MNRE test projects on village energy security goes beyond electrification by addressing the total energy requirements for cooking, electricity, and motive power with a focus on use of biomass energy. 90% of the capital cost of the test projects would be met through central grant, subject to a benchmark of Rs.20,000/- per beneficiary household for meeting the total domestic and community energy requirements. There are 81 test projects under implementation in 10 States of which 54 projects have been commissioned. (**Ministry of New and Renewable Resources, GOI)**

(iv) National Biogas and Manure Management Programme (NBMMP), since 1981**.** The Central Sector Scheme on National Biogas and Manure Management Programme, is mainly focused to setting up of family type biogas plants. National Biogas and Manure Management Programme provides for central subsidy in fixed amounts, turn-key job fee linked with five years' free maintenance warranty; financial support for repair of old-non functional plants; training of users etc. The Programme provides Central Financial Assistance (CFA) of Rs 2100to Rs14700 per family depending upon the capacity of the plant location and the status of family. (**Ministry of New and Renewable Resources, GOI)**

(v) Solar Photovoltaic (PV) Programme, since 1982

A country wide Solar Photovoltaic Demonstration Programme is being implemented by the MNRE for more than two decades. The Programme is aimed at developing cost effective PV technology and its applications for large-scale diffusion in different sectors, especially in rural and remote areas. Major components of the solar PV programme include, RandD demonstration and Technology utilization, Testing and standardization, Industrial and promotional activities etc.

The following solar PV systems are covered under the solar PV programmes of MNRE:

Solar Home Lighting Systems/Solar Home Systems

Solar Lanterns

Solar Street Lighting Systems

Stand-alone PV Power Plants

Solar PV Water Pumping systems

Other applications of solar PV Technology including new applications.

vi) National Biomass Cook stoves Initiative (NBCI), since 2009

It covered enhancement of technical capacity in the country by setting up testing, certification, monitoring facilities and strengthening RandD programmes in key technical institutions. The dominating focus is put on health impacts by improving combustion efficiency, avoiding the generation of pollution.

The project is focusing on improving the technical capacities for improved cookstoves in India through:

Setting up of regional test centers

Improving test protocols and standards

Strict monitoring R and D

Pilot projects implemented through the state nodal agencies of MNRE.

(2) NGOs and Other Donors:

Appropriate Rural Technology Institute (ARTI): This NGO, established in April 1996 by a group of scientists, technologists and social workers, to develop and transfer innovative, sustainable technologies to rural people for income generation and to improve their quality of life.

AVANI: It is a voluntary organization working in the Kumaon region of Uttarakhand (middle range of Central Himalayan region). Avani is working in solar systems, solar water heaters, solar driers, pine needle gasification and biogas.

Environmental Defense Fund (EDF): It is a US national nonprofit organization. In India, EDF is currently implementing village-level development programmes following a cross-sectoral approach including energy in the form of biogas plants, stoves, solar systems, covering about 100,000 households. A programme on milk cooling devices for rural milk collections unit is under development with a Norwegion company.

Mahatma Gandhi Institute for Rural Industrialization (MGIRI): It is a National Institute under the Ministry of Micro, Small and Medium Enterprises, Govt. of India. MGIRI has with support of MNRE developed several solar-powered devices for rural applications, e.g. solar spinning wheels, air coolers, grinders and potter's wheels. However, there have been no attempts to bring these products to the market on a larger scale.

Prayas: It is a Pune-based Research NGO with focus on policy research in the areas of health, energy, resources and livelihood, learning and parenthood. Prayas is conducting research on RE policy, just starting to get involved in issues to off-grid renewable energy.

Breathing Space: This programme tackles the 'silent killer in the kitchen' - the fumes inhaled by people cooking on smoky fires and stoves, (which is responsible for a 1.5 million premature deaths worldwide) by promoting and selling improved stoves through a market-oriented approach.

SAMUHA: it is an NGO working in six districts of Karnataka as Raichur, Koppal, Haveri, Gadag, Uttara Kannada and Bangalore Urban. It is a charitable trust which explores, supports and enhances social enterprises.

The Energy and Resource Institute (TERI):

The institute based on gasifier technology for industrial thermal applications, Gasifier technology for rural electrification, Gasifiers for cold storage in rural areas funded by World Bank. It works on improving solar lantern design, solar multi-utility, smart mini grids and biomass stove development along with their distribution.

Vasudha Foundation: It was set up to promote environment. Main areas of work are policy advocacy, climate Negotiations, engaging multi-lateral agencies, demolishing myths and State Climate Action Plans.

3.9.1. Key objectives for national energy policies

There are four key objectives of our national energy policy:

1) Access at affordable prices

2) Improved security and Independence

3) Greater Sustainability

4) Economic Growth

1) Access at affordable prices:

National energy policies are going to provide electricity to nearly 304 million people, and clean cooking fuel to nearly 500 million people, which still depend on biomass. The policy aims to ensure that electricity reaches every household by 2022. Considering poverty in India, access to energy for all at affordable prices is on prime importance.

2) Improved security and Independence:

Today, India is heavily dependent on oil and gas imports while also importing coal. Improved energy security, normally associated with reduced import dependence, is also an important goal of the policy.

3) Greater Sustainability:

The goal of sustainability acquires importance and urgency in view of the threat of dangerous effects of climate change as well as the effects of fossil fuel usage on local air quality. In India, sustainability is also closely linked with energy security. This means that cutting fossil fuel consumption would promote the twin goals of sustainability and security.

4) Economic Growth:

The energy policy must support the goal of rapid economic growth. Efficient energy supplies promote growth in two ways. First, **energy is the lifeblood of the economy**. It is an important enabling factor of growth and its availability at competitive prices is critical to the competitiveness of energy-intensive sectors. Second, **being a vast sector in itself**, its growth can directly influence the overall growth in the economy. For example, petroleum products are an important direct contributor to our growth in recent years by attracting large investments in refining/distribution, and also fuelling economic activity.

With four broad objectives of our energy policy, we need to link them to propose actions on the ground. The areas are classified according to the source (coal, oil gas or renewable) or form (electricity) of energy and the stage of value chain. Stages of value chain are divided into:

A) **Upstream**: Upstream stage of electricity is <u>generation</u>.

B) **Midstream**: Midstream is <u>transmission</u> of electricity.

C) **Downstream**: It is the <u>distribution</u> of electricity.

Final consumption of energy is analyzed according to four major consumption sectors as: businesses, households, transportation, and agriculture.

3.9.2. Areas of intervention

Our schematic division allows us to identify seven areas of intervention which are as follows:

(i) Energy Consumption by businesses, households, transportation and agriculture.

(ii) Energy Efficiency/de-carbonisation measures on the demand side.

(iii) Production and distribution of coal.

(iv) Electricity generation, transmission and distribution.

(v) Augmenting supply of oil and gas, both by domestic EandP, and through acquisition of overseas acreages.

(vi) Refining and distribution of oil and gas.

(vii) Installation, generation and distribution of renewable energy.

In the past years insufficient attention has been paid to robust institutions and regulation issues in India. The present policy focuses more centrally on this aspect. There are important achievements to be had from the introduction of well-functioning institutions for value addition in the chains associated with different energy sources.

The policy in India focuses on **two horizons**: a short term horizon going up to 2022 and a medium term going all the way up to 2040. The time frame up to 2022 is short enough that it allows us to discuss interventions that are required right away while the period up to 2040 is long enough to contemplate bolder interventions that are required to fully modernize India's energy sector.

In the past, the challenge of meeting both objectives resulted in sacrificing one for the other. Global experience tells us that the two are actually two sides of the same coin, and the two are complementary.

The NEP proposes actions to meet the objectives in such a way that India's economy is 'energy ready' in the year 2040. Technological advancements and global energy markets are rapidly changing. All four major energy-consuming sectors as industry, household, transport, and agriculture will undergo dramatic changes in the coming decades. Urbanization is expected to go up to 47%, while current share of manufacturing in the GDP will double to 30% by the year 2040.

3.10. Role of State Governments

The State Governments will be encouraged to set prices in net-metering solutions in a manner that balances the interests of consumers and market. The State Governments have a major role in development of renewable energy as both local infrastructure and purchase support, which can only be provided by states. As far as the Central Government is concerned, it will support the state agencies and not directly engage in generation element. The national agencies such as SECI, IREDA and government RandD institutions will continue to provide various kinds of support such as channelizing funds, providing project execution know-how, and power purchase/payment assurance through state governments.

As the Central Government alone cannot meet these large expectations, the role of State Governments in HRD is acknowledged and their support to this agenda in a big measure. The existing robust engagement of State Governments in higher education needs to be extended to specialized technical disciplines including the energy sector ones. Even the private sector institutions look upon the States to support their efforts to set up technical institutions. States will appreciate that their programmes of clean energy deployment, and other interventions related to the energy sector (e.g. **Smart cities**, **Electric vehicle deployment**, **Decentralized renewable energy solutions in villages** etc.) will need high quality energy professionals.

NITI Aayog will offer a platform to bring the Central Ministries and State Governments together to solve the inter-agency issues related to integration and growth of Renewable Energy in the country as per the Renewable Energy Integration Roadmap 2030.

Industry-Academia collaboration: On the basis of the data the energy sector companies would fund/sponsor/support educational institutions to set up colleges/Universities/ITIs/polytechnics in the specialized disciplines sought by them.

Few State Governments have taken a lead in setting up energy related institutions of higher learning, which needs to be remedied as local Governments best appreciate the job opportunities existing in their energy installations.

3.11. New Technologies

Arrangements will need an upgrade. There is a need to set up **Renewable Energy Management Centers** (REMCs) in all States to handle issues arising out of variable renewable electricity. Renewable Energy can also be generated from off-shore locations for which a National Off-shore Wind Policy has already been announced in 2015. Similarly, **floating solar panels** on reservoirs, lands held by government institutions and public buildings including government housing may diversify generation, and ease stress on land. Islands, hilly areas and remote locations ought to be the prime candidates for application of off-grid renewable sources of electricity supply.

Rooftop solar has vast potential across different categories of consumers, both for power generation and supply of heat. It has also been estimated that this technology is already viable for commercial and industrial consumers. Even in urban areas, rooftop solar has become cost effective. This is all the more essential if the target of achieving 40GW target by 2022 from non-grid connected solar is to be achieved.

The large Renewable Energy programme will require land, which is a scarce commodity in many States. It will, therefore, be essential to promote mega solar power plants only on wastelands and non-agricultural tracts.

For this, **small sized solar plants** (up to 50 MWp) need to come up across the country in rural areas especially at the end of the transmission lines. This will reduce the size of plots, which ought to be purchased on commercial basis, and will not be dependent on state intervention in making land available. The co-benefit would be lesser challenge to grid integration.

Another related emerging technology is of **Electric Vehicles** that can also double up as a storage device. Suitable directetions will be applied to encourage EVs to store-up renewable energy when it is available in excess of demand.

3.12. Human Resource Development

Energy sector is a fine example of integration between the interests of job creation and supply of a critical input. India has a challenge to provide job opportunities to its vast young population. For instance, solar and wind renewable energy is estimated to have created jobs in India. The petroleum sector requires specialists in geology, geo-physics, drilling and production, while the electricity sector requirements are in instrumentation, civil engineering, electrical and electronics/IT. Similarly, the requirements of coal, renewable and nuclear power are different, too. Both technical and managerial skills will be the focus of interventions in creation of a new HRD cadre for energy sector. Many of these new positions will be in the nature of energy; while at the other extreme, skilled technicians will be required for routine functions. A Skill India Mission is already at work and the NEP must generate the opportunities in the energy sector with it. As regards specialists, an industry-academia collaboration is required to identify the niche areas and plan for their availability.

- Quality and not just Quantity: The large employment prospects in the energy sector must not be misconstrued so, in order to ensure top quality of manpower, our HRD initiatives will be so deployed that they incubate the best in class professionals. For this, collaborations between our academic institutions and the globally best ones in selected domains will be forged. Energy sector is witnessing rapid change as technology evolves, and our manpower needs to be abreast with them. The same institutions are the source of researchers who will be a critical ingredient of our energy related RandD initiatives.

3.13. Vision 2040 of India in energy sector

India Vision 2040 aims to answer the above precise question. Demand-driven provision of energy at affordable prices, high per capita consumption of electricity and access to clean cooking energy and electricity with universal coverage, low emission and security of supply will characterize the energy parameters of India in 2040.

The Indian energy market will have fully evolved with supply rising to meet demand on the basis of competitive markets. The trend of rising private sector share in supplies of electricity, oil, gas, coal, and renewable in production and trade will transform the market by 2040. The large Indian energy market will drive competition between sources of energy and also within the same source. The role of markets in lowering the price of solar and wind energy and LED bulbs has already been witnessed. Smart grids and storage solutions hold a great future for a country like India that wishes to achieve a large share of renewable electricity. Therefore, markets and technology are expected to define the energy scenario of India in 2040, called the **NITI Ambition Scenario (NAS)**, 2040.

3.14. SUMMARY

- **In this unit we have discussed various aspects based on global and national status which will be highly helpful for you to understand:**
- ***Global energy consumption in 2018, led by natural gas, even as solar and wind posted double digit growth. The biggest requirement came from natural gas, which emerged as the fuel of choice last year. The global economy***

challenges in terms of meeting its energy needs in the coming decade. The increasing energy requirements coupled with domestic fuel production.

- *That in India, majority of population reside in rural areas and are still dependent on non-commercial energy sources, such as fuel wood, crop residue, and animal waste for their energy needs. Total energy requirement, especially in the rural household sector, is met by non-commercial energy sources. Building new refineries, coal and gas fired power stations. Reducing cross subsidies on oil products and electricity tariffs.*
- *Investment legislation to attract foreign investments. Streamlining approval process for attracting private sector participation in power generation, transmission and distribution.*
- *That the world energy demand in different sectors is based on primary energy demand, demand for electricity, demand of solar and wind energy will continue at an unprecedented rate and create new opportunities and challenges for energy systems.*
- *Demand for Coal and Crude oil along with transitioning Global Transport.*
- *The World Energy Council aims to provide a wide range of insights into the current status and future of the world's energy industry through its different flagship studies.*
- *The evolution of international governance structures and the nature of state rivalry have a significant impact on economic and energy policies and the pattern of energy trade. The UN's charter enshrined the veto rights of the five permanent members of the Security Council as China, France, Russia, the United Kingdom, and the United States.*
- *About new technologies, including the full diffusion of information, sensing and communication, automation and health technologies which have the potential to reshape economic and social options. For example, fully driverless Electric Vehicles (EVs) are fast becoming a reality. The combinatorial effect of battery technology, GPS, machine learning and*

analytics have created the right environment to accelerate what was previously seen as niche development or a longer-term change.

- ***At global level we have various international agencies for making different reports to make an outlook on the status of energy. These reports generate a status on the production and consumption of energy based on demand and supply concept. The agencies/ ministries/ regional associations/ councils and regulators are located or acting in different countries.***
- ***The different programmes to meet out the demand at national levels as under Indian government/ NGOs and different agencies are going to make the country more progressive.***
- ***We are using four key objectives of our national energy policy as 1) Access at affordable prices 2) Improved security and Independence 3) Greater Sustainability and 4) Economic Growth. The State Governments have a major role in development of Renewable Energy as both local infrastructure and purchase support; can only be provided by States.***
- ***India Vision 2040 aims to answer the above precise question. Demand-driven provision of energy at affordable prices, high per capita consumption of electricity and access to clean cooking energy and electricity with universal coverage, low emission and security of supply will characterize the energy parameters of India in 2040.***

Terminal Questions

Q.1.) In India, a population of over 1.21 billion as per **……..** census with 70% of total population living in rural areas. Out of these 1210 million people the 396 million does not have access to electricity and 592 million people still use **……….** for cooking. Majority of these people reside in **…….** areas and are still dependent on non-commercial energy sources, such as fuel wood, crop residue, and animal waste for their energy needs. Furthermore, about 80% of the population - which includes 28% of urban inhabitants - still relies on combustion of **……..** fuels for **……..** activities.

Q.2.) What do you mean by Energy Strategies for a Sustainable World?

Q.3.) Explain energy policies and the Role of state Governments in brief.

Q.4.) Define the role of world energy scenarios.

Q.5.) The optimum utilization of existing assets is also known as:

a) Immediate term strategy **b)** Medium-term strategy **c)** Long term strategy **d)** None

Q.6.) Full form of NOC is:

a) Non Objective Companies **b)** National Oil Companies **c) a** and **b** both **d)** None

Q.7.) Work of WEC is divided into thirteen resource-specific work groups, called:

a) Knowing Neighbors **b)** Know Nexus **c**) Knowledge Networks **d) a** and **b** both

Q.8.) Which is not the key objective for national energy policies:

a) Fossil Fuels **b)** Improved security and Independence c**)** Greater Sustainability

d) Economic Growth

Q.9.) Full form of HRD is:

a) High Density Diode **b)** Human resource Department c**)** a and b both **d)** Human Resource Development

Q.10.) As the Central Government alone cannot meet these large expectations, the role of **………..** in **……..** is acknowledged and their support to this agenda will be taken in a big measure. The existing robust engagement of State Governments in **………..** needs to be extended to **……….** technical disciplines including the energy sectors. Even the private sector institutions look upon the States to support their efforts to set up technical institutions. States will appreciate that their programmes of **………** deployment, and other interventions related to the energy sector (e.g. **Smart cities**, **Electric vehicle deployment**, **Decentralized renewable energy solutions in villages** etc.) will need high quality energy professionals.

Q.11.) Write the full form of:

(a) NOCs **(b)** EVs **(c)** WEC **(d)** CERC **(e)** AERB **(f)** ERRA **(g)** RGGVY **(h)** IESS **(i)** REMCs **(j)** NAS

<u>Answers:</u>

Q.1.) 2011, firewood, rural, biomass, cooking.

Q.2.) Pls. refer 3.2.1

Q.3.) Pls. refer 3.3.1

Q.4.) Pls. refer 3.4

Q.5.) a)

Q.6.) b)

Q.7.) c)

Q.8.) a)

Q.9.) d)

Q.10.) State Governments, HRD, higher education, specialized, clean energy.

Q.11.)

(a) National Oil Companies **(b)** Electric Vehicles **(c)** World Energy Council **(d)** Central Electricity Regulatory Commission **(e)** Atomic Energy Regulatory Board **(f)** Energy Regulators Regional Association **(g)** Rajiv Gandhi Grameen Vidyutikaran Yojana **(h)** India Energy Security Scenario **(i)** Renewable Energy Management Centers **(j)** NITI Ambition Scenario **.**

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UNIT 4: Conventional Energy Sources-I: Biomass based energy resources-Fuel wood, Firewood, Dung cake and Agricultural residue

Unit Structure

4.0 Learning Objectives

After studying this unit you will be able to explain:

- What is the importance of energy resources in our life?
- What is the Biomass?
- What are types of Biomass and uses of Biomass?
- About Firewood and its uses.
- About Fuel wood and its uses
- About Cow dung and its uses
- What is Agriculture residue?

4.1. Introduction

As you know that energy is capacity to do work, it is directly or indirectly in the entire process of evolution, growth and survival of all forms of life. The primary source of energy on earth is Sun. Besides the Sun various types of energy sources such as biomass, hydropower, nuclear power, bio-fuel, wind energy source etc are also available on earth. Like other natural resources energy resources are also renewable and non-renewable.

Renewable energy resources are mostly biomass based and are available in unlimited amount in nature since these can be renewed over relatively short period of time. Biomass energy is renewable energy source and being used in different parts of earth. Production of biomass energy has large or vast scope for innovation and its application in rural areas. For this purpose we require efficient resources, as sustainable, renewable and non-conventional to full fill the potential of India. Biomass energy acts like treasures of renewable energy at global level. Biomass energy is totally depends on biological components. These biological components may be plants, animals and microbes. In this unit you will learn about biomass and their uses and types.

4.2. Conventional energy

As you know conventional energy has been used for a long time. There are various types of conventional energy sources such as coal, petroleum, fossils fuel, biomass etc. Human being use conventional energy source since human civilization therefore, these types of energy resources are depleting very fast. However, conventional energy resources are still main energy resource for economical development of nation. The conventional energy sources are fixed and limited in natural environment. These energy resources are also known as non-renewable energy sources. The use of conventional energy sources may lead into climate change, global warming, ozone layer depletion acid rain etc. because these sources release certain harmful gases in the atmosphere. Literally, conventional means which has established itself by convention or common over long years by usage. Different sources of energy are shown in Figure 1.

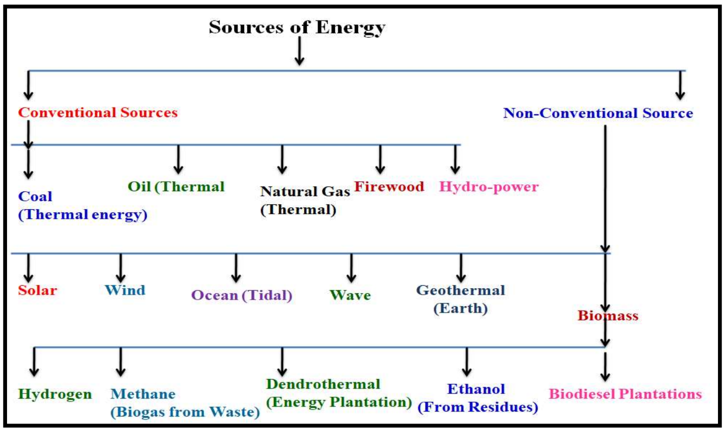

Figure-1: Different energy sources

4.3. Meaning of Biomass

Literally Biomass means Bio=Life and mass means= put together. Therefore, biomass is any organic matter such as wood, crops, seaweed, animal wastes. The biomass is source of energy and that can be used as an energy source. Biomass is possibly our oldest resource of energy after the sun. For thousands of years, people have burned wood and cow dung to heat their homes and cook the food.

Biomass gets its energy from the sun. All organic matter contains stored energy from the sun. During a process called photosynthesis, sunlight gives plants the energy they need to convert water and carbon dioxide into oxygen and sugars. Foods rich in carbohydrates are a good source of energy for the human body. Biomass is a renewable energy source because its supplies are not limited.

4.4. Types of Biomass

There are many types of biomass today, including wood, agricultural products, solid waste, landfill gas and biogas, and biofuels. There are various types of biomass which are summarized in Figure 2 and also given below:

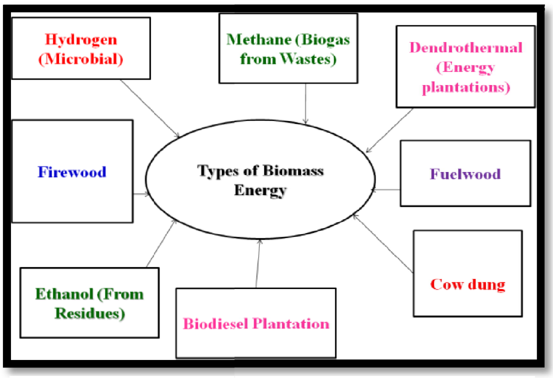

Figure-2: Types of Biomass energy sources

Hydrogen: Hydrogen energy can be generated by the living components such as bacteria. The hydrogen energy can be produced with the help of gasification. Gasification is the process in which organic matter convert into CO, H2 and CO2.

Methane: Methane gas can be produced with the help of certain microbes. When biomass is burned it produced CO2 and methane. The methane gas is used for cooking as well as heating. Methane may be found in Compressed Natural Gas (CNG) and used as fuel for vehicles.

Dendrothermal: It is also type of biomass energy. In this type of energy trees (woody plants) are used to generate electricity or energy.

Fuel wood/Firewood: As you know that fuel wood energy depends on the woody plants. Human being used this type of biomass energy since its civilization.

Cow dung: traditionally cow dung is used as fertilizers and it is type of biomass energy, because it contains organic matter. It is green energy source and used for heating engine, cooking food etc.

Biodiesel: It is vegetable oil. It is chemically mono-alkyl ester.

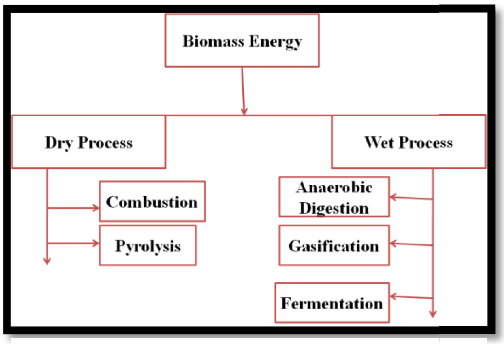

Figure- 3. Processes of biomass energy production

Biomass Production Processes: The processes by which biomass energy can be produced are given in Figure 3. The biomass energy formation may be produced by two general processes viz. dry process and wet process. The dry process further divided in to three process combustion, pyrolysis and gasification. On the other hand wet process classified into anaerobic digestion and fermentation.

Combustion: Combustion is the efficient way of extracting energy from biomass and the technology of direct combustion. Combustion systems are available in wide range of shapes and sizes. Some system utilizes fuel in the form of kitchen manure and agricultural waste or residue like straw, hay, husk, tree trunks, municipal refuse and scrap tires. In some systems the heat emitting from burning waste is used for water heating, industrial processing and electric generation.

Gasification: It is a process which produces a flammable gas. This process mainly utilizes wood and produces gas mixture of H_2, CO, CH_4 and other non-flammable by-products. This process is done by partially burning and partially heating the biomass, a natural by-product of burning biomass is formed which is known as charcoal. The use of petrol in cars can be replaced by gas, which reduces the pollution emitted by vehicles up to 40%. In the coming future the power stations will utilize this fuel as a major source of energy. Typical chemical composition of producer gas is given as:-CO 18-20%, H_2 15-20%, CH_4 1-5%, CO_2 9-12%, N_2 45-55%. Calorific value of producer gas is in the range of 1000-1200 kcal/m (Sharma, 2018)

Pyrolysis: A vast range of energy fuel can be generated by smouldering of hay, husk, dry wood, straw and wood chips. This process is under practice since ancient times to produce charcoal. The material is grinded or blended then charged into a reactor and heated in the vacuumed flask. Pyrolysis can also be performed in the small presence of O2 (gasification) water (steam gasification) or H2 (hydrogenation), CH4 (methane) is the most efficient fuel used for electricity generation using high efficiency gas turbines.

Anaerobic Digestion : The process of producing biogas in the absence of O2 using wet sewage, sludge, animal dunk or green plants are allowed to decompose in sealed tank. Wood chips, straw, hay, husk can also be used but the digestion takes much longer time. 1 kg of organic material can be expected to yield 450-500 liters of biogas. The residue left after decomposition is a valuable fertilizer or manure. (Sharma, 2018)

Fermentation: Ethyl alcohol is generated by the fermentation of sugar solution and natural yeast. Feedstock such as crushed sugar beet and fruit sugar can be manufactured by cellulose and vegetable starches by pulping or cooking or from cellulose by treating it with acid. When the fermentation process completes for 30 hours, the solution contains 6-10% alcohol, which can be removed by distillation process (Sharma, 2018)

4.4.1. Firewood/ Fuel wood

As it is earlier mentioned that firewood or fuelwood is biomass based energy in which woody plants are used for production of energy. Though other source of energy like LPG, agricultural waste, coal charcoal, biogas, kerosene and electricity are also used for cooking in Indian households, fuel-wood is the major source in rural area.

Most biomass used today is home grown energy. Fuel wood accounts for about 42% of biomass energy. But any organic matter can produce biomass energy. Wood and wood waste are being used to produce electricity. Much of the electricity and useful heat at the same time is used by the industries making the waste; it is not distributed by utilities, this process called cogeneration. Paper mills and saw mills use lot of their waste products to generate steam and electricity for their use. However, since they use so much energy, they need to buy additional electricity from utilities. Increasingly, timber companies and companies involved with wood products are seeing the benefits of using their lumber scrap and sawdust for power generation.

Table-1: Annual fuel-wood consumption (Million tonnes) **(Source: Forest Survey of India, GOI, Dehradun)** (Sharma, 2018) with year

State/UT	Quantity of fuel-wood used	Quantity of fuel-wood used from forest	% of total consumption used from forests
Andhra Pradesh	24.2	2.9	12.2
Arunachal Pradesh	0.41	0.3	80.9
Assam	11.4	2.4	21.8
Bihar	11.4	0.4	4.0
Chhatishgarh	4.3	1.3	31.5
Gujarat	9.7	2.2	22.8
Haryana	1.4	0.0	0.1
Himachal Pradesh	1.2	1.1	95.8
J&K	1.3	1.0	72.8
Jharkhand	4.8	2.8	58.5
Karnataka	20.9	5.7	27.5
Kerala	14.5	2.1	15.0
Madhya Pradesh	13.6	7.1	52.6
Maharashtra	9.5	4.5	47.6
Orissa	8.8	2.9	33.4
Punjab	3.3	0.0	0.8
Rajasthan	18.7	3.6	19.6
Tamil Nadu	12.3	2.6	21.0
Uttar Pradesh	19.0	1.2	6.7
Uttarakhand	2.5	2.1	83.3
West Bengal	14.1	6.3	44.9
North Eastern States	5.2	3.8	72.4
Union Territories	2.6	1.2	48.3
TOTAL	**215.11**	**57.5**	**27.14**

As per 2011 census, almost 85% of rural household were dependent on traditional biomass fuels for their cooking energy requirements. According to National Sample Survey (2009-10) the percentage of household depending on fuelwood was 76.3% a drop only 2% point since 1993-94, although the percentage using LPG has increased from 2% to 11.5% over the same period. Annual fuelwood consumption by different states/UTs of India is shown in Table-1.

Fuelwood is chiefly consumed by Andhra Pradesh, Assam, Bihar, Gujarat, Karnataka, Kerala, MP, Maharashtra, Orissa, Rajasthan, Tamil Nadu, UP and West Bengal. In India only 58.74 million tones of the fuelwood was available from natural forests in the year 2011. This quantity coming from the forests is 27% of the total fuelwood consumption in the India. The remaining fuelwood comes from plantation on non-agricultural land, degraded forest land, cultivable wasteland, barren land, permanent pastures and grazing land. (Sharma, 2018)

Softwoods are not weaker than hardwoods. Softwoods come from coniferous trees such as cedar, fir, and pine and tend to be somewhat yellow or reddish. Because, most of the coniferous trees grow straight. Hardwoods are more expensive than softwoods.

Commercial pines are grown in plantations for timber that is denser, more resinous, and therefore more durable than spruce. Pine is very easy to work with and, because most varieties are relatively soft, it lends itself to carving. Pine is commonly used in furniture because it's easy to shape and stain. Pine generally takes stain very well (as long as you seal the wood first). Pine wood is widely used in high-value carpentry items such as window frames, paneling, floors and roofing, and the resin of some species is an important source of turpentine. It's also relatively easy to find sustainable grown softwoods (woods grown on tree farms to ensure an endless supply of wood).

There are over 200 species of oak in commercial cultivation. English Oak is known to the best quality and has been used for 1000's of years. Oak is strong and easier to work with when green. It is also resistant to moisture and is very durable. The wood is very resistant to insect and fungal attack because of its high tannin content.

Oak planking was common on Viking long ships in the 9th and 10th centuries. The wood was hewn from green logs, by axe and wedge, to produce planks. Boards of oak have been prized since the Middle Ages for use in interior paneling of prestigious buildings such as the debating chamber of the House of commons in London. It is also commonly used in improving digestion, prevent diabetes, keep also bones healthy and also improve metabolism.

Ash is a hardwood and is hard, dense, tough and very strong. It is very useful for making tool handles and baseball bats due to its elasticity. Ash has great finishing qualities. It also has good machining qualities, and it is also easy to use with nails, screws and glue.

It is also frequently used as material for electric guitar bodies. Some Fender Stratocasters and Telecasters are made of ash. It is also used for making drum shells. Early cars had frames which were intended to flex as part of the suspension system in order to simplify construction. Morgan cars still have frames made from ash.

Ethanol is an alcohol fuel (ethyl alcohol) made by fermenting the sugars and starches found in plants and then distilling them. Any organic material containing cellulose, starch, or sugar can be made into ethanol. The majority of the ethanol produced in the United States comes from corn. New technologies are producing ethanol from cellulose in woody fibers from trees, grasses, and crop residues.

Characteristics of Ethanol

With one of the highest octane ratings of any transportation fuel, ethanol increases the energy efficiency of an engine. When using ethanol blends, vehicles have comparable power, acceleration, payload capacity, and cruising speed to those using gasoline. Ethanol is also less flammable than gasoline; it is safer to store, transport, and refuel.

Vehicle maintenance for ethanol-powered vehicles is similar to those using gasoline. Oil changes, in fact, are needed less frequently. Due to its detergent properties, ethanol tends to keep fuel lines and injectors cleaner than gasoline. Because ethanol has a tendency to absorb moisture, using ethanol fuel can help reduce the possibility of fuel-line-freeze-up during the winter.

Economics of Ethanol

The Federal Government mandated that by 2012, 12 billion gallons of renewable fuels be produced per year. The U.S. is exceeding this mark, producing nearly 15 billion gallons of ethanol alone in 2016. For comparison, however, the U.S. consumed over 143 billion gallons of gasoline in 2016. Today, it costs more to produce ethanol than gasoline, however, federal and state tax advantages make ethanol competitive in the marketplace.

Since it is the second largest use of corn, ethanol production adds value to crops for farmers. As new technologies for producing ethanol from all parts of plants and trees become cost-effective, the production and use of ethanol will increase dramatically.

Environmental Impacts

Ethanol is water soluble and biodegradable. If a fuel spill occurs, the effects are less environmentally severe than with gasoline. Because ethanol contains oxygen, using it as a fuel additive results in lower carbon monoxide emissions. The E10 blend results in 12 to 25 percent less carbon monoxide emissions than conventional gasoline. E10 is widely used in areas that fail to meet the EPA's air quality standards for carbon monoxide. However, some research indicates that under common driving conditions E10 can increase ozone concentrations. Breathing ozone in unhealthy concentrations can result in damage to the lungs and cause coughing and shortness of breath. In contrast to E10, E85 reduces ozone-forming volatile organic compounds and carbon monoxide. (Sharma, 2018)

Compared to gasoline, the production and use of corn ethanol could result in little to no carbon dioxide reductions in the near future. This is because an increased demand for ethanol may lead to converting forests and grasslands to crop land for fuel and food. This conversion releases carbon dioxide into the atmosphere. When these factors are taken into account, switching to corn ethanol from gasoline would provide little or no climate change benefit in the next 50 years. However, the production and use of cellulosic ethanol could reduce CO_2 emissions by 18 to 25 percent compared to gasoline, even when the impacts from clearing land for crops are considered.

Biodiesel contains virtually no sulfur, so it can reduce sulfur levels in the nation's diesel fuel supply, even compared with today's low sulfur fuels. While removing sulfur from petroleum-based diesel results in poor lubrication, biodiesel is a superior lubricant and can reduce the friction of diesel fuel in blends of only one or two percent. This is an important characteristic because the Environmental Protection Agency now requires that sulfur levels in diesel fuel be 97 percent lower than they were prior to 2006.

Biodiesel exceeds diesel in cetane number, resulting in superior ignition. The cetane number is the performance rating of diesel fuel. Biodiesel also has a higher flash point, or ignition temperature, making it more versatile where safety is concerned. Horsepower, acceleration, and torque are comparable to diesel. Biodiesel has the highest Btu content of any alternative fuel, though it is slightly less than that of diesel. This might have a small impact on vehicle range and fuel economy.

Biodiesel is available throughout the United States, mainly through commercial fuel distributors. There are relatively few public pumps that offer biodiesel. With only a few more than 200 biodiesel fueling stations, it is a more practical fuel for fleets with their own fueling facilities. Availability for consumers is steadily expanding as demand grows.

Environmental Impacts

Biodiesel is renewable, nontoxic, and biodegradable. Compared to diesel, biodiesel (B100) reduces sulfur oxide emissions by 100 percent, particulates by 48 percent, carbon monoxide by 47 percent, unburned hydrocarbons by 67 percent, and hydrocarbons by 68 percent. Emissions of nitrogen oxides, however, increase slightly (10 percent). Biodiesel blends generally reduce emissions in proportion to the percentage of biodiesel in the blend. (Sharma, 2018)

4.4.2. Dung Cake/Cow dung

Animals can play an important role in the provision of energy either in negative way where livestock keeping contributes to deforestation in large parts of forested area or in positively, such as by trans- forming plant energy into useful work or by providing dung used for fuel through dung cakes or biogas to replace charcoal, fuel wood, firewood etc. Most livestock products in mixed farming systems are derived from animals that are fed on local resources such as pasture, crop residues, fodder trees and shrubs. Animals (cows, bullocks and milk buffaloes) provide dung and urine to enrich the soil, while crop residues and fodder form the bulk of the feed for these animals. There are a variety of cow dung and cow's urine products, which can be used as fertilizers and pest repellent respectively in agricultural practice.

These products are very popular and are using day by day. Low soil fertility is one of the greatest biophysical constraints to production of agro-forestry crops across the world. Cow dung is a very good source for maintaining the production capacity of soil and enhances the microbial population. But due to increasing population pressure and demand of food resources, there is a need of introducing a chemical fertilizer, pesticides and insecticides to the soil, which are disturbing the soil physiochemical properties including soil texture, porosity, and water holding capacity and also disturbed the soil microbial population.

Dung cake is dry faecal matter of animal which is used as a fuel source. The dung cake has been used as fuel since time immemorial. The dung cake used as fuel in many countries around the world. Camel dung has been used in Egypt. Cows dung is a most important source of bio-fertilizer.

Shortage of fuel wood is a major problem which forces the rural people to use a dung cake for their fuel purpose, which effects on the productivity status of cultivated land. Dung cake is a good resource for maintaining the productivity status and enhances the beneficial microbial population of soil.

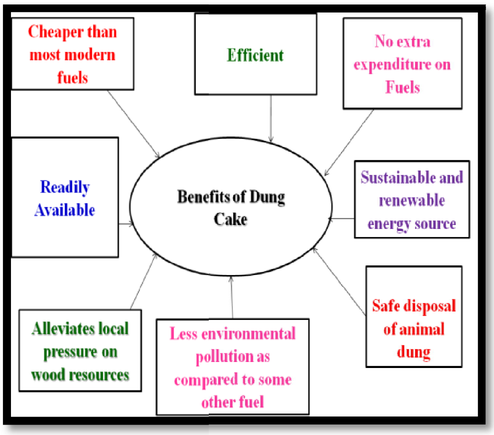

Figure-4: Different uses of Dung cake

Cow-dung is very effective's manures for reducing the bacterial and fungal pathogenic disease. It showed positive response in suppression of mycelial growth of plant pathogenic fungi like Fusarium solani, F. oxysporum and Sclerotinia sclerotiorum.

Benefits of Dung Cake: There are various benefits of dung cake which are summarized in figure 4.

4.4.3. Agricultural residue

Agricultural biomass is a relatively broad category corn is one example of the food-based portion of a crop. It is primarily fermented into ethanol. Agricultural biomass that includes: The food-based portion of crops (such as corn, sugarcane, and beets), the nonfood-based portion of crops such as corn stover, the leaves, stalks, and cobs, orchard trimmings, rice husks, perennial grasses, and animal waste. Traditionally, there have been high costs associated with recovering most agricultural residues, and therefore, they have not yet been widely used for energy purposes. However, they can offer a sizeable biomass resource if technology and infrastructure are developed to economically recover and deliver this type of biomass to processing facilities.

Food-based Portion of Crops: The food-based portion of crops is the part of the plant that is either oil or simple sugars. Rapeseed, sunflower, soybeans, corn, sugarcane, and sugar beets are all examples of this type of agricultural biomass. The sugar from corn, sugar beets, and sugar cane are commonly fermented to produce ethanol. Oilseed crops such as rapeseed, sunflower, and soybeans can be refined into biodiesel.

Nonfood Based Portion of Crops (Complex Carbohydrates): The nonfood based portion of crops is the part of the plant that is commonly discarded during processing for food production. This category includes materials such as corn stover; wheat, barley, and oat straw; and nutshells. Stover and straw are fermented into ethanol. Nutshells are typically refined into biodiesel or combusted for heat. Due to the important function of crop residues in erosion protection and overall soil quality, care must be taken on a site-by-site basis to ensure sustainability.

4.5. Uses of Biomass

There are various uses of Biomass. As you know that biomass is produced through fermentation. Yeast is added to biomass waste such as wood and agricultural waste to produced ethanol. Therefore, biomass is used for production of fuels. Biomass energy is also used to generate electricity. Powerhouse use heat and steam produced by burning organic matter to generate electricity. In present time, biomass is producing electricity which is being supplied to 1.3 million homes in USA. The biomass energy also being used in thermal burning. By burning solid biomass materials, we gain energy to fuel our houses and industries such as water heating, cooking and washing. It is the most common and domesticated use of the biomass energy in our daily life.

4.6. Advantages and disadvantages of Biomass Energy

There are various advantages and disadvantages of Biomass energy which are summarized in Fig-5 and Fig-6 and also described below:

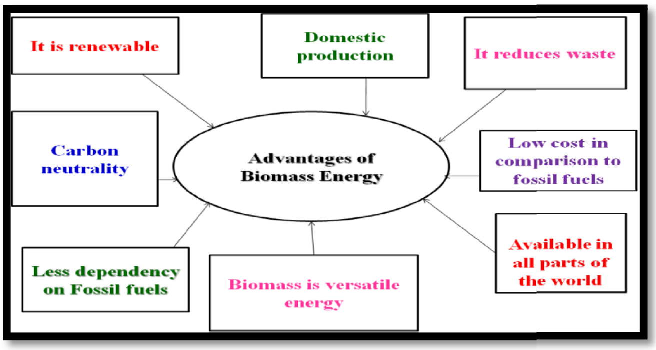

Figure-5: Advantages of biomass energy

<u>It is renewable:</u> Biomass energy can be replenished after use. Biomass fuel such as wood, plants can be re-grown therefore it is regarded as renewable source. However, for this Sun, water etc. are needed for maintenance.

Carbon neutrality: As you know that CO_2 is major contributor of global warming and climate change. Biomass energy minimizes this because the fuel is a natural part of carbon cycle. The carbon dioxide released in air from biomass energy is that carbon which was absorbed by plants during photosynthesis. The plants again absorbed the carbon di oxide this phenomena makes biomass energy clean.

Low dependency on fossils fuel: When we use more biomass energy, the less we need fossils fuel and can minimize the environmental issues.

Biomass energy is versatile: It is also amongst the most versatile alternative available. It can be converted into many different fuel sources, each of which has varied applications. Wood can be utilized to produce heat while steam produced by biomass energy can also power turbine to generate energy.

More availability: The biomass energy is more abundant in nature like Sun and water. The biomass available in every part of the earth.

Low cost as compared to fossil fuels: The collection of biomass energy required minimum cost. If we compared the cost of biomass energy to fossil fuels we will find that drilling for oil or preparing gas pipelines required more costs. The biomass energy also reduces the bills of consumers. The low cost production of biomass energy makes biomass more attractive to producers.

Biomass energy reduces the waste: Biomass energy does not produce any manmade waste product in nature. Biomass energy production only produces biodegradable waste which is not as harmful to the nature.

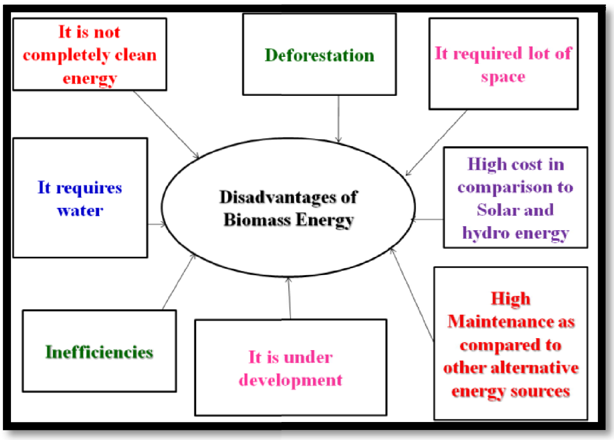

Figure-6 Disadvantages of biomass energy

Disadvantages of Biomass energy:

Biomass energy is not completely clean: However biomass is a carbon neutral fuel source, it is not completely clean. Wood burning releases other emission to the atmosphere and these harmful emission can pollute the environment, even the effects are not as drastic as compared to other fossils fuel.

High cost as compared to other alternatives: The costs of biomass energy is comparably low as compared to fossil fuels but when we compare the costs of biomass energy with solar energy and hydropower energy, the cost of biomass energy is high.

Deforestation: Biomass fuel mostly taken from the forests therefore it can cause deforestation which is certainly one of the major environmental issues of present time. Deforestation also leads into extinction of wildlife.

More space required: Large amount of space also needed to grow the biomass material. This type of space is always not available specially in cities and built up areas. This makes biomass energy less favourable as compared to solar power.

Biomass energy required water: This is also unseen disadvantages of the biomass energy. The large amount of water required in the production of biomass energy. All living things needs water to live which means source must be available at all times.

Under development: If we compare biomass energy to solar and water energy sources, biomass is inefficient and under researched.

4.7. Status of Biomass energy in India

India is much rich in natural resources and has a potential of about 18GW of energy from the biomass. In present time, approximately 32% of the total primary energy used in country is derived from biomass. (Sharma, 2018)

About 75% of population of India lives in rural areas and uses about 40% of total energy of the country. Consumption pattern of rural areas is sector energy use (%) domestic 64% agriculture 22% industrial/commercial 7% lighting 4% transportation 3.% biomass fuels and animal energy are the two main non-commercial energy sources used in rural India; Biomass fuels include fuel wood, crop residues, animal wastes and Gobar gas. The percentage contribution of each of these biomass fuels is 65, 30 and 15% respectively, on an average. (Sharma, 2018)

The fuel wood consumption ranges from 146-300 MT/year and the demand is increasing with rise in population growth. Out of the total power generated in the country, the potential of the animal energy is close to 50%. This is mainly for farming operations and transportation. There are about 84 million of draught animals which is equivalent to 30,000 MW of power.

Amongst the conventional sources of commercial energy used in India, coal is the prime resource. In present day context; 60% of coal produced is utilized in generation of electricity, which in fact, is more than 95% of the thermal power or about 70% of total installed capacity of electricity generated in India. (Sharma, 2018)

About 40% of petroleum products are used for providing raw material in fertilizer, plastics, synthetic fibres, rubber, pesticides, various pharmaceutical and, organic chemical industries. The consumption of petroleum products has increased at a much faster rate in the last few years and at present 66 million tones of petroleum products (1994-95) are being used out of which 50% is imported.

Natural gas consumption has shown an increase in the recent years. The annual gas supply has increased from 10 billion m^3 in 1990 to 16 billion m3 in 1990. (Sharma, 2018)

The hydropower electricity is not yet fully harnessed. At present we are using only 25% of the total hydropower potential of our country. Nuclear power in Indian context is yet to take off. Four nuclear power stations with installed capacity of 2005 MW are working efficiently.

However, nuclear hazards resulting from any careless handling can be disastrous. Table-1 gives a summarized view of conventional sources of commercial energy in our country.

Plants like Jatropha, curcas, neem, mahua, taad, barley, and other wild plants may be used for the production of biodiesel. There are about 63 million hectare of land in India which is not in use, out of which 40 million hectare area can be used for the plantation of

Jatropha, curcas. India induced villagers to rehabilitate such waste lands through the cultivation of Jatropha. The Indian government had planned earlier for the plantation of Jatropha on 11.2 million hectare of land area by 2012. The Ministry of New and Renewable Energy (MNRE) provides Central Financial Assistance (CFA) in the form of capacital subsidy and financial incentives to the biomass energy projects in India. CFA is allotted to those projects which have best efficiency, energy production and its utilization etc. (Sharma, 2018)

Future of biomass energy depends on providing reliable energy services at competitive cost. In India, this will happen only if biomass energy services can compete on a fair market. Sustained supply of biomass shall require production of energy crops (e.g. wood fuel plantations, sugar cane as feedstock for ethanol) and wood plantations for meeting growing non-energy needs. Due to increasing prices of chemical fertilizer and non-efficient role in long term to sustainable production, there is a need of application of organic manure including cow dung for enhancing maximum productivity in sustainable way with better soil health. Due to increasing prices of chemical fertilizer and non-efficient role in long term to sustainable production, there is a need of application of organic manure including cow dung for enhancing maximum productivity in sustainable way with better soil health.

4.8. Summary

In this unit we have discussed various aspects of biomass based energy resources. So far you have learnt that:

- ***The primary source of energy on earth is Sun. Besides the Sun various types of energy sources such as biomass, hydropower, nuclear power, bio-fuel, wind energy source etc are also available on earth. Like other natural resources energy resources are also renewable and non-renewable.***
- ***Conventional energy has been in use for a long time. There are various types of conventional energy sources such as coal, petroleum, fossils fuel, biomass etc. These types of energy resources are depleting very fast.***

However, conventional energy resources are still main energy resource for economical development of nation.

- ***Literally Biomass means Bio=Life and mass means= put together. Therefore, biomass is any organic matter such as wood, crops, seaweed, animal wastes. The biomass is source of energy and that can be used as an energy source.***
- ***There are various types of biomass energy such as hydrogen, dendothermal, methane, fuelwood, firewood, cow dung, biodiesel, ethanol etc.***
- ***The biomass energy is obtained mainly by the different processes such as Combustion, gasification, pyrolysis, anaerobic digestion, fermentation etc.***
- ***Most biomass used today is home grown energy. Fuel wood accounts for about 42% of biomass energy. But any organic matter can produce biomass energy. Wood and wood waste are being used to produce electricity. Much of the electricity and useful heat at the same time is used by the industries making the waste; it is not distributed by utilities, this process called cogeneration.***
- ***Animals can play an important role in the provision of energy either in negative way where livestock keeping contributes to deforestation in large parts of forested area or in positively, such as by trans- forming plant energy into useful work or by providing dung used for fuel through dung cakes or biogas to replace charcoal, fuel wood, firewood etc.***
- ***Dung cake is dry faecal matter of animal which is used as a fuel source. The dung cake has been used as fuel since time immemorial. The dung cake used as fuel in many countries around the world. Camel dung has been used in Egypt. Cows dung is a most important source of bio-fertilizer.***
- ***There are various benefits of dung cake and these benefits are: it is cheper than the modern fuel, it is efficient, no extra expenditure on fuels, it is***

sustainable and renewable, disposal is easy, less environmental pollution as compred to some other fuels.

- ***Agricultural biomass is a relatively broad category Corn is one example of the food-based portion of a crop. It is primarily fermented into ethanol.***
- ***There are various uses of Biomass. Yeats is added to biomass waste such as wood and agricultural waste to produced ethanol. Therefore, biomass is used for production of fuels. Biomass energy is also used to generate electricity. Powerhouse use heat and steam produced by burning organic matter to generate electricity. In present time, biomass is producing electricity which is being supplied to 1.3 million homes in USA.***
- ***The biomass energy also being used in thermal burning. By burning solid biomass materials, we gain energy to fuel our houses and industries such as water heating, cooking and washing. It is the most common and domesticated use of the biomass energy in our daily life.***
- ***There are various advantages of biomass energy such as : it is renewable, carbon neutrality, low dependency on fossils fuel, biomass energy is versatile, More availability, low cost as compared to fossil fuels, biomass energy reduces the waste.***
- ***There are few disadvantages of biomass energy such as biomass energy is not completely clean, it has high cost as compared to other alternatives, it may leads into deforestation, it required more space, biomass energy required water and this technology is under development.***
- ***India is much rich in natural resources and country has a potential of about 18GW of energy from the biomass. In present time, approximately 32% of the total primary energy used in country is derived from biomass.***

TERMINAL QUESTIONS

Q.1. (a) Fill in the blank spaces with appropriate words.

In………. vast range of energy fuel can be generated by smouldering of hay, husk, dry wood, straw and wood chips. This process is under practice since ancient times to produce………….. The material is grinded or blended then charged into a reactor and heated in the vacuumed flask. ……….can also be performed in the small presence of O_2 (……………) water (………….. ……….) or H2 (…………), CH_4 (methane) is the most efficient fuel used for electricity generation using high efficiency gas turbines. In Anaerobic Digestion producing biogas in the absence of …….using wet sewage, sludge, animal dunk or green plants are allowed to decompose in sealed tank. Wood chips, straw, hay, husk can also be used but the digestion takes much longer time. 1 kg of organic material can be expected to yield 450-500 liters of biogas. The residue left after decomposition is a valuable ……….or ………..

Q.2. (a) Define the conventional energy sources.

(b) What is biomass energy? Explain

Q. 3. (a) Describe the fuelwood/firewood and its status in India.

(b) Give the two process of biomass energy production

Q. 4. a) Define agricultural residue? Write about its use in biomass energy

Q. 5. (a) What do you understand by dung cake?

(b) Discuss the advantages and disadvantages of biomass energy

(c) What are the benefits of dung cake? Explain

Q.6. (a) Fill the blank spaces with appropriate words.

India is much rich in ……….resources and country has a potential of about ………. of energy from the biomass. In present time, approximately ……….. of the total primary energy used in country is derived from biomass. About 75% of population of India lives in ……….areas and uses about ………….. of total energy of the country. Consumption pattern of rural areas is Sector Energy use Domestic ………..Agriculture …………Industrial/Commercial ………Lighting ……….Transportation ………..Biomass fuels and animal energy are the two main non-commercial energy sources used in rural India; Biomass fuels include fuel wood, crop residues, animal wastes and…………… …... The percentage contribution of each of these biomass fuels is 65, 30 and 15% respectively, on an average.

(b) Which energy is totally depends on biological components (Solar/Hydro/Nuclear/Biomass)

(c) Dung Cake mostly used in (Rural Areas/Urban Areas)

(d) Conventional energy sources are also known as (Renewable/**Non-renewable**)

(e) What is fermentation and pyrolysis?

Q.7. (a) Give the status of biomass energy in India.

ANSWERS

1 (a) pyrolysis, charcoal, Pyrolysis, gasification, steam gasification, hydrogenation, O_2, fertilizer, manure

2 (a) see section 4.2.

(b) See section 4.3

3 (a) See section 4.4.1

(b) See section 4.4 including fig-3.

4 (a) See section 4.4.3

5 (a) See the section 4.4.2

(b) see the section 4.6 including fig-5 and fig-6.

(c) See section 4.4.2 including fig-4

6 (a) natural, 18GW, 32%, rural, 40%, 64%, 22%, 7%, 4%, 3.%, Gobar gas

(b) Biomass

(c) Rural Area

(d) Non-renewable

(e) See the section 4.4 in headings fermentation and pyrolysis.

7 (a) See the section 4.7

Reference

1. Ministry of New and Renewable Energy Resources https://mnre.gov.in/bio-energy/current-status

2. Sharma, P.D. (2018). Text book on Ecology and Environment 13th edition. ISBN: 978-93-5078-122-7.

UNIT 5 Conventional energy sources II: Hydropower, Coal, Oil, Natural gases

Unit Structure

5.0. Learning Objectives

After going through this unit you would be able to know the following:

- What is the importance of energy resources in our life?
- Meaning of hydropower and its importance
- Meaning of coal energy and its importance
- Meaning of oil and its importance
- Meaning of natural gas and its importance

5.1. Introduction

Energy affects every part and every field of our life. We need energy to do all sorts of physical and physiological activities like moving writing, running, cooking, thinking or doing any work. We need energy for transportation, communication, lighting, industries and agriculture. We also need energy to extract minerals from ores and to manufacture fertilizers, pesticides and all other products. We need energy for space travel and all scientific activities. Thus, we see there is hardly any aspect of life which we can think of that does not require energy. In fact, energy use is an indication of the degree of development. Some 99 % of the energy used to heat our earth and all our buildings comes directly from sun. Without this direct input of solar energy our earth's temperature would have been 240°C and life would just not have been possible. The 99% of the energy coming from sun to the earth is natural and not sold in the market. The remaining one percent is the commercial energy used by people in different forms like fuel wood, coal, oil, dung, electricity etc.

The energy sources can be broadly categorized into renewable and nonrenewable resources. While renewable resources like biomass energy, solar energy, tidal energy, wind energy, hydro-power energy etc. can be regenerated, the non-renewable energy resources like coal, petroleum and natural gas are fossil fuels which took millions of years to be formed and cannot be renewed during our life span.

5.2. Hydropower

Hydropower is recognized as a renewable source of energy, which is economical, non-polluting and environmentally beneficial. Hydropower projects involve the construction of dams to produce the waterfalls that power turbines. Although hydropower is renewable, the dams and reservoirs needed to capture this energy have limited life spans. The reservoirs behind dams invariably filled with sediments, giving the typical dam a life span of 20 to 100 years. Once a hydropower site is filled with sediments, it is gone forever. Dams also often create many environmental problems. This means that hydroelectric power is unlikely to expand much faster in developed as well as developing countries.

Because of the escalating cost and environmental damage from large dams, many of these countries have developed small hydropower plants (“Minihydro:-less than 10 MW and “microhydro”-less than, 1 MW) in remote areas to supply electricity. China has built over eighty thousand such small projects and the United States has nearly fifteen thousand. However, these small hydropower plants will not solve the problem of how to supply energy to the huge and rapidly growing cities of developing countries (Sharma, 2018)

5.2.1. Hydro-power Potential in India

India has a large hydro power potential totaling about **1,48,700 MW**, which can be used. However, **75%** of it is concentrated in the **Himalayan region**, which is tectonically very unstable. The history of hydropower generation in India is more than **100 years old**. The first-hydropower station in India was a small hydropower station of 130 KW commissioned in **1897** at **Sidrapong** near **Darjeeling** in **West-Bengal**. Subsequently, many small hydropower stations were set up. With the advancement in technologies and increasing requirement of electricity, emphasis was shifted to large sized hydropower stations. The growth of hydropower in the country since 1990 to 2000 is shown in Figure 1. This hydropower capacity is about 25 percent of the total installed capacity for electricity generation. **Ministry of Power** in the Government of India is responsible for the development of large hydropower projects in India, while MNRE has recently been assigned to develop small hydropower projects (**3-25 MW**) in the country. (Sharma, 2018)

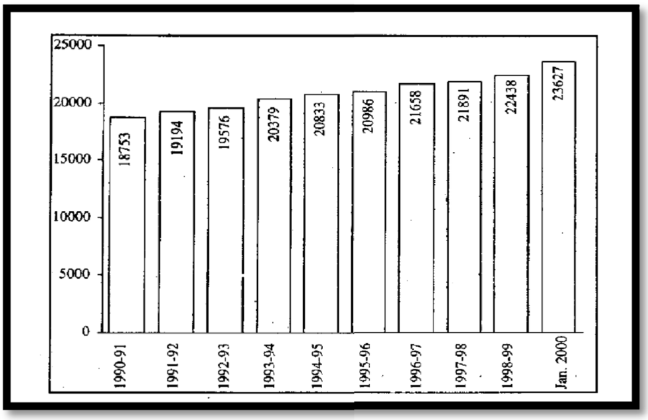

Figure 1: The growth of hydropower in the country (installed power generating capacity in MW)

An estimated potential of about 10,000 MW of small hydropower projects exists in India. MNES has identified 3349 sites with an aggregate potential of 2,852 MW for small hydro projects up to 3 MW capacity and 662 sites with an aggregate potential of 5,519 MW for projects upto 3-15 MW capacity. Presently, the country has exploited 217 MW with the construction of 271 small hydropower projects (up to 3 MW capacity). Over 130 projects in this range, with an aggregate capacity of 133 MW, are under construction. In the last 10 years, the capacity of small hydro projects has increased 3 fold from 63 MW to 217 MW. Table 4 lists the existing and ongoing small hydro power plants in the country as on June 1997. (Sharma, 2018)

Table-1: State-wise small hydropower projects in India (Sharma, 2018)

	Projects installed		Projects under construction	
State	**Number**	**Capacity (MW)**	**Number**	**Capacity (MW)**
Andhra Pradesh	7	7.01	36	42.10
Arunachal Pradesh	30	20.15	17	20.63
Assam	2	2.20	-	-
Bihar	4	0.04	5	2.46
Goa	-	-	2	2.90
Gujarat	1	2.00	2	2.60
Haryana	1	0.20	1	0.10
Himachal Pradesh	15	9.49	18	11.19
Jammu and Kashmir	15	4.37	10	11.20
Karnataka	8	10.10	22	30.64
Kerala	4	3.52	6	14.00
Madhya Pradesh	5	3.25	8	14.40
Maharashtra	4	4.32	5	8.70
Manipur	6	4.10	4	3.50
Meghalaya	1	1.51	7	0.28
Mizoram	9	5.36	9	8.80
Nagaland	5	3.17	4	5.50
Orissa	3	1.26	7	9.92
Punjab	4	3.90	8	9.50
Rajasthan	5	4.30	2	1.04

5.2.2. Important Hydropower projects at Global level

Human being used hydropower since time immemorial. As you know that human being civilized near the rivers and aquatic bodies. There are various dam constructed over the many rivers of the world. Three Gorges dam in China is largest dam of the world which constructed over the Yangtze River. The capacity of this dam is about 22.5GW. There are various important hydropower projects constructed over different rivers of world which are summarized in Table-2.

Table-2: Largest dams at global level (Sharma, 2018)

S.N.	Name of Dam	Generation Capacity	Name of River on which dam constructed	Name of Country
	Three Gorges Dam	22.5GW	Yangtze River	China
	Itai Pu Dam	14 GW	Parana River	Brazil
	Xiluodu Dam	13860 MW	Jinsha River	China
	Guri Dam	10235 MW	Caroni River	Venezuela
	Tucurui Dam	8370 MW	Tocantins River	Brazil
	Xingjiaba Dam	6400 MW	Jinsha River	China
	Grand Colie Dam	6809 MW	Columbia River	United State
	Long Tan Dam	6426 MW	Hongshui River	China
	Krasnoyarsk Dam	6000 MW	Yenisei River	Russia
	Robert Bourassa	5616 MW	La Grande River	Canada

5.2.3. Important Hydropower projects at National level

India is the home to many rivers. The mighty Ganga, Yamuna, Kaveri, Narmada, Satluj, Krishna etc. are the main river of Country. The dams have various importance such as water supply, electricity generation, aquaculture etc. The highest dam of India is Tehri Dam which constructed over Bhagirathi river in Uttarakhand. The installed capacity of the Tehri Dam is 1000 MW. The longest dam of the India is Hirakund dam which constructed over Mahanadi river in Stare Orissa. There are also various important hydropower projects such as Nagarjun Sagar dam, Maithon Dam, Sardar Sarovar Dam, Rihand Dam etc are also constructed over the different rivers of India. These dams are socio-economicvally very important for the country. The important dam, their installed capacity, height and length is given in Table-3. (Sharma, 2018)

Table-3: Some important dams of India, their location and capacity (Source: Energy statistics, 2017)

Name of Dam	River	State	Installed Capacity (MW)	Height	Length
Nagarjuna Sagar dam	Krishna	Andhra Pradesh	816 MW	124 meters	1,450 meters
Maithon dam	Barakar	Jharkhand	60 MW	165 ft	15,712 ft
Tilaiya dam	Barakar	Bihar			
Sardar Sarovar dam	Narmada	Gujarat	1,450 MW	163 meters	1,210 meters
Bhakra Nagal dam	Satluj	Himachal Pradesh	1325 MW	226 meters	520 meters
Tungabhadra dam	Tungabhadra	Karnataka	72 MW	49.38 meters	2441 meters

Krishnarajasagar dam	Main Cauvery	Karnataka	200 MW	125 feet	3.5km
Cherothoni dam	Cheruthoni	Kerala	32 MW	450 feet	2300 feet
Indira Sagar Dam	Narmada	Madhya Pradesh	1,000 MW	92m	653 m
Koyana dam	Koyna	Maharastra	1,920 MW	339 ft.	2,648 ft
Hirakud dam (longest dam of India)	Mahanadi	Odisha	307.5 MW	60.96 meters	25.8 km
Bisalpur Dam	Banas River	Rajasthan	172 MW	130 ft.	1883 ft
Bhavani Sagar dam	Bhavani	Tamil Nadu	32 MW	105 ft	1700 m
Maitur Dam	Kaveri River	Tamil Nadu	120 MW	120 ft.	1700 m
Tehri dam (highest dam of India)	Bhagirathi	Uttarakhand	1,000 MW	260 meters	575 meters
Rihand dam	Rihand	Uttar Pradesh	300 MW	299 ft	3064 ft

5.2.4. Advantages and disadvantages of hydropower (dams)

There are various advantages and disadvantages of Dams which are summarized in Fig-4 and also discussed below:

Cleans Energy: Dams are very important to produce electricity by using the energy of moving water. In this process kinetic energy of the river turns the wheel and converted into mechanical energy. Dams provide almost 20% of the world's electricity. China, Canada, Brazil, the United States, and Russia were the five largest producers of hydropower in 2004. (Sharma, 2018)

Irrigation: This is one of the most important advantages of hydropower. Most of the rivers of India flow in more than one state and hence irrigation is a controversial aspect in India. But irrigation in India has been dominated by construction of major and medium projects. In the present time, water scarcity is common problem for farmers of all around globe. Dams provide adequate amount of water for irrigation. This water generally used during the drier period. As you know dams store large amount of water, then in the summer or drier period, it may be released dam and distributed in agricultural land through different channels/canals. As you know about 70% of water resources have been used for irrigation purpose. Several irrigation projects such as Bargi project (Madhya Pradesh), Beas Project

(Haryana, Punjab, and Rajasthan), Bhadra Project (Karnataka) have been implemented in India.

Aquaculture: Aquaculture is cultivation of aquatic organisms specially fishes. Since, dams provide sufficient amount of water (stagnant), high plankton diversity, sufficient water depth and other suitable conditions to the fishes. Therefore dams also provide aquaculture opportunities to communities.

Navigation: Population explosion certainly leads in to high pressure on roads, therefore many Governments of World looking for their alternative. As you known the condition of rivers are very dangerous, due to erosion, sedimentation etc. Dams provide stable water system of river transportation.

Recreation: Dams also provide prime recreational facilities throughout the world. Boating, skiing, camping, boat launch facilities are all supported by dams. There are various dams which are also used as recreational purpose, such dams are Nagarjuna Sagar Dam, Iddukki Dam, Tehri Dam, Hirakund Dam, Bhakra Nagal Dam, Sardar Sarovar Dam etc.

Flood control: Dam also helpful is flood control, since there dams can be effectively used to regulate level of river & prevent flood in downstream. Flood control is a main purpose for many of the existing dams.

Water Supply: Scarcity of water is common problem for whole world. Dams provide adequate amount of water supply to local communities. Dams store water for irrigation in summer seasons and dry months. Many desert areas can now farm due to dams and canals that supply water.

Disadvantages of Hydropower or Dams: The few disadvantages of dams are summarized in Fig- and also described below:

Prevent flow of River: Dams obstruct the natural ecological flow of river. As you know that natural ecological flow of river is responsible for sustainability of river. Due to obstruction in ecological flow many biodiversity of river going to threatened or are verge at extinction. Ecological flow maintains the biodiversity and water of riverine ecosystem. development of dam on river can change the species composition and water quality of river.

Chances of catastrophic flood: The enormous weight of water behind the dam could trigger seismic activity that might damage the dam and can lead in to catastrophic flood. As you know that catastrophic flood are more dangerous as compared to alluvial flood, coastal flood and other forms of flood. Catastrophic flood can submerge the cities within few hours.

Can cause harm to migratory fishes: As a result of dam construction and holding of sediments in reservoirs, sediment feeding of downstream channel or shore beaches is prevented. As the transfer of sediments is avoided by this way, the egg lying zone of the fishes living in the riverine ecosystem is eroded, too. Normal passing ways of territorial animals are hindered since the dam acts as a barrier. Migration is typical character of some migratory fishes is which fish moves from one place to another place for different purposes (food, reproduction, etc) especially for breeding purpose. Due to construction of dams many Diadromous fishes (fish which moves from fresh water to sea water or vice versa) cannot migrate. Due to construction of dam the fish movement may be stopped or delayed. The Dam prevents migration of fishes between feeding & breeding zones.

Change in Water Quality: Some dams loose so much water through evaporation and seepage into porous rock beds that they waste more water than they make available. Salt left behind by evaporation increase the salinity of the river and make its water unusable when it reaches the downstream. Accumulating sediments in the storage reservoir not only makes dams useless but also represents a loss of valuable nutrients to the downstream agricultural lands.

Water logging: Water logging is the saturation of soil with water. Soil may water logged due to high water level. Water logged can reduce air in soil and increase in soil salinity, loss of useful biological community etc. According to Indian Institute of Science, about 40% of command area of Sardar Sarovar Dam will be water logged.

Social and Cultural impacts: Dams also affect the social, cultural aspects of the concern region considerably, specially forcing people, whose settlement areas and lands remain under water to migrate. Dams affect their psychology negatively. It is estimated that 400-800 million people have been affected by dams at global level. For example in Africa

350,000 people were displaced due to construction of dams during 1970s. Three Gorges Dam in China has displaced 1.4 million people.

5.3. Coal

It is black or brown in colour, sedimentary rock of earth and formed due to the heat of the earth. Coal began to form 225 to 350 million years ago in the hot regions of the earth. Ancient plants flourished in and along the banks of lakes, streams and coastal swamps; leaves fell into water and got accumulated on the bottom. Their rate of accumulation was much faster than their rate of decomposition. Eventually, this rich organic material was covered by mud or sediment eroded from the land, and over time, heat and pressure converted the organic material into peat and then coal.

Coal seams can be 100 meters thick and can extend over tens of thousands of square kilometers in areas that were once vast swamp forests in the pre-historic times.

The value of coal as a fuel was first discovered in 12th or 13th century by the inhabitants of the north east coast of England. Coal is the organic fossil material which is solid and black in colour with varying properties and composition. It is essentially rich in amorphous carbon and contains several liquid and gaseous hydrocarbons.

India has about 5% of world's coal production. Coal, besides a prime source of industrial energy is also a raw material. Coal including lignite even today accounts for 60% of country's commercial requirements. Major coal fields in India are Raniganj, Jharia, East Bokaro and West Bokaro, Panch-Konkan (Tawa Valley), Singrauli, Takhar, Chanda-Wardha and Godavari Valley. The major states known for coal reserves are Bihar, Orissa, West Bengal, Madhya Pradesh, Andhra Pradesh and Maharashtra.

By and large, the quality of Indian coal is rather poor in terms of heat capacity. This poor heat capacity can be converted into electricity and gas and even oil. That is the reason why many of out thermal power stations are located on the coal fields to produce electric power to feed regional grid. Coal production in India which was just 35 million tons in 1951 went to over 180 million tons in 1988-89. Per capita consumption of coal has increased from 135 kg to nearly 225 kg. Lignite (brown coal) is generally a low quality coal. But Indian lignite has less ash than coal. The deposits at Neyveli (Tamil Nadu) are about 3,300 million tons, which is about 90% of India's lignite reserves. It produces 600 MW of thermal power.

5.3.1. Types of Coal

There are various types of coal, on the basis of characteristics, heating value, carbon and volatile matter, coal is divided into four categories viz. anthracite, bituminous, lignite and peat. The different types of coal are summarized in Figure 2 and also discussed below:

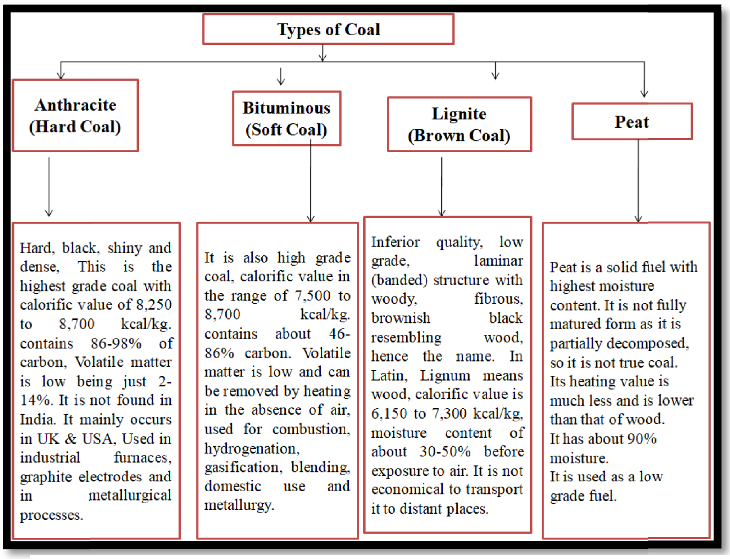

Figure 2: Different types of coal and their characteristics

A. Anthracite (hard coal): It is hard, black, lustrous, shiny and dense coal. Anthracite coal is the highest grade coal with calorific value of 8,250 to 8,700 kcal/kg, it contains 86-98% of carbon content. In anthracite coal the volatile matter is low being just 2-14%. It is not found in India, however, low amount available in State Jammu and Kashmir. It is mainly found in UK, USA and Australia. India imported Anthracite coal from Australia. Anthracite coal is used in industrial furnaces, graphite electrodes and in metallurgical processes. (Sharma, 2018)

B. Bituminous: It is also called soft coal and high grade coal next to anthracite. It has a calorific value in the range of 7,500 to 8,700 kcal/kg. It contains about 46-86% carbon. Volatile matter is low and can be removed by heating in the absence of air, when it gets converted into coke. More the volatility, lower is the heating value. It is used for combustion, hydrogenation, gasification, blending, domestic use and metallurgy. It is found in India in the region of West Bengal, Jharkhand and Orissa. (Sharma, 2018)

C. Lignite: It is also called Brown coal. Lignite is inferior quality, low grade coal. It has laminar (banded) structure with woody, fibrous, brownish black appearance, resembling wood, hence the name. In Latin, Lignum means wood. Calorific value of lignite coal is about 6,150 to 7,300 kcal/kg. It has a moisture content of about 30-50% before exposure to air. Its volatile matter is about 30%. Due to high moisture, rapid oxidation and low heating value, it is not economical to transport it to distant places. It is burned in pit head power plants. It is found in regions of Tamil Nadu, Assam, Rajasthan and Jammu and Kashmir. (Sharma, 2018)

D. Peat: Peat is a solid fuel with highest moisture content. It is not fully matured form as it is partially decomposed, so it is not true coal. Its heating value is much less and is lower than that of wood. It has about 90% moisture. It is used as a low grade fuel. It is regarded as precursor of coal formation. (Sharma, 2018)

5.3.2. Important Properties Of Coal

The most important properties of coal for energy evaluation are follows:

a. Moisture: It is an important property of coal. Ground water and other extraneous moisture is known as adventitious moisture. Moisture which is available in coal is called inherent moisture. Inherent moisture is analyzed quantitatively. The moisture can found in four possible forms viz. Surface moisture (water held on the surface of coal particles or macerals), Hygroscopic moisture (water held by capillary action), decomposition moisture (water held within the coal's decomposed organic compounds), mineral moisture (water which comprise part of the crystal structure of hydrous silicates such as clays).

b. Volatile matter: Volatile matter in coal refers to the components of coal, except for moisture which are liberated at high temperature in the absence of air. this is usually a mixture of short and long chain hydrocarbons, aromatic hydrocarbons and some sulfur.

c. Ash: Ash content of the coal is the non-combustile residue left after coal is burnt. It represents the bulk minerals matter after carbon, oxygen, sulfur and water has been driven off during combustion. It also give an indication about the quality of coal.

d. Fixed carbon: The fixed carbon content of the coal is the carbon found in the material which is left after volatile materials are driven off. This is different from the carbon content of the coal because some carbon is lost in hydrocarbons with the volatiles.

e. Relative density: RD or specific gravity of the coal relies on the rank of the coal and degree of mineral impurity. Knowledge of the density of each coal play is necessary to determine the properties of composites and blends. The density of the coal seam is necessary for conversion of resource into reserves.

Coal Production and Processing

Various production technologies involve exploration, mining, preparation, sorting, cleaning, storage and transportation. The coal conversion technologies include coal gasification, liquefaction, coal slurry, coal carbonization for coke and coal gas production.

Coal mining is done in two distinct ways:

Surface mining, in which the coal beds are near the ground surface with little over-burden of soil (depth < 30 m).

Underground mining - here the coal beds are located at depths.

After mining, the coal is prepared to make it suitable for a particular use. The coal is purified by removing dirt, mud etc. and sulphur is also removed because sulphur present in coal is responsible for high SO_2 emissions on burning. Coal is converted from solid form to liquid or gaseous form also. Various solid, and gaseous fuels have their specific application. Direct burning of coal results - emission of particulates, smoke, SOx - NOx, CO and CO_2, The gaseous or liquified fuels cause lesser pollution. Some important coal conversion technologies are discussed below :

Coal Gasification: It involves chemical reaction of coal, steam and air at high temperature. A coal water mixture called a Slurry is injected with oxygen into a heated chamber, producing three combustible gases: Carbon monoxide, hydrogen and some methane. The heated gas is then cooled and purified. The resultant gas bums as cleanly as natural gas. This gas can be used for domestic purposes. Figure 3 shows a schematic diagram of the gasification technology.

An efficient coal gasification process, in this process coal particles mixed with water are sprayed into a heated furnace (gasifier) where steam and combustible gases are produced.

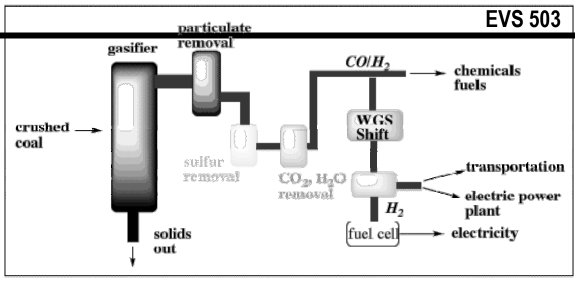

Figure 3: Coal Gasification Process

The gases are then cleaned by passing them through water. The gases of next burned and the exhaust gas is used to spin one of two electrical generators. The heat is also captured to generate steam, which operates another generator. (Sharma, 2018)

Fluidized Bed Combustion: While burning coal, a lot of pollution occurs. So there is a need to burn coal in cleaner way. Fluidized Bed combustion is one such important technology, in while coal is crushed and mixed with bits of limestone and propelled into a furnace in strong current of air. The particles mix turbulently in the combustion chamber ensuring very efficient combustion and therefore, low levels of carbon monoxide are produced. The furnace also operates at a much lower temperature than a conventional coal boiler, thus reducing nitrogen oxide emissions. The limestone reacts with sulphur oxides producing calcium sulphite or sulphate, thus reducing SOx emissions from the stacks.

Fluidized bed combustion: This process burns crushed coal blown into a furnace mixed with tiny limestone particles. The air turbulence in the furnace ensure thorough combustion, thus increasing efficiency. The limestone reacts with sulfur oxide gases moving most of them from the smokestack. Steam pipes in the furnace help maximize heat efficiency. (Sharma, 2018)

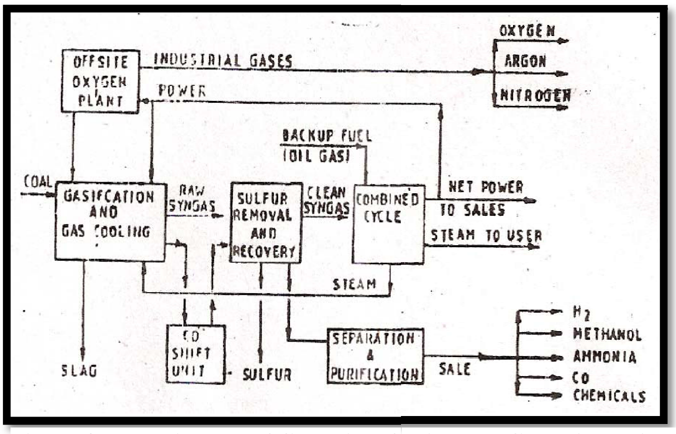

Figure 4. Flow diagram of Coal Liquefaction and Coal Dissolution

Coal Liquefaction:

Coal can also be treated to produce a thick, oily substance by liquefaction. At least 4 major processes now exist which add hydrogen to coal to produce oil. The oil can then be refined like crude oil to produce a variety of products like jet fuel, gasoline, kerosene, many chemicals, drugs and plastics. Coal liquefaction is a costly process and it generates pollutants like phenols. It also does not help in CO_2 emission reduction.

5.4. Oil

The commercial sources of energy include petroleum, coal, natural gas and nuclear energy. Out of all these oil is the most widely used energy resource.

Oil (Petroleum) Oil is the life line of global economy. The identified deposits from which oil can be extracted profitably at present prices with current technology are known as oil resources. Thirteen countries of the world make up the Organization of Petroleum Exporting Countries (OPEC), which have 67% of these reserves. About one fourth of the oil reserves are located in Saudi Arabia. It is further estimated that the undiscovered oil will also be just located in Middle East Thus, the world oil supplies and prices are likely to be controlled by OPEC over a long period of time. (Sharma, 2018)

United States of America is the world's largest consumer of oil using 30% of global total, whereas it has only 4% of the world's oil reserves. Maximum use of oil is in transportation (63%), followed by industry (24%), residential and commercial buildings (8%) and electric utilities (8%). At the present rate of consumption, the world's crude oil reserves are estimated to be depleted in 40 years and there may be enough undiscovered oil lasting for another 40 years: Some analysts argue that rising oil prices will stimulate exploration and that the earth's crust may contain more oil than is generally thought. Such oil even if it exists, lies about 10 kilometers or still more below the surface (twice the depth of wells known today). (Sharma, 2018)

It was in 1859, when a steel drill in Pennsylvania hit 20 meters and a black, foul smelling liquid came gushing from a well. This was the dawn of a new energy era. This was petroleum and just less than a century later, this oil became the world's most important energy resource. Being liquid and relatively easy-to transport long distances, either by ship or by pipeline, oil has been accepted as an ideal fuel. It burns cleaner than coal, but less cleaner than natural gas. (Sharma, 2018)

Oil is also obtained from oil shales and sand tars. Oil Shale is a grayish brown sedimentary rock that was formed millions of years ago from the mud at the bottom of lakes. Within the rock is contained a solid organic material called as, kerogen. When heated to high temperatures, the rock gives off its oily residue called Shale oil. High grade oil shale can produce upto 120 litres of shale oil per ton of rock. Like petroleum, shale oil can also be refined to produce gasoline, jet fuel, kerosene and a variety of feed stocks used by chemical industry to produce fabrics, drugs and plastics.

Tar sands are found in some parts of the world where oil is found to have migrated into neighbouring layers of sandstone, creating tar sands. The thick oily residue, called bitumen can be extracted from the rock and refined to produce a variety of fuels and chemicals in much the same way that shale oil is processed.

5.4.1. Impacts of oil on Environment

As you know oil comes from wells on land and at sea. The impacts of oil on the sea are very important. During handling and transportation lot of pollution is known to occur. Crude petroleum contains hydrocarbons; sulphur, nitrogen, oxygen and several heavy metals.

During handling, oil pollution occurs at the following stages:

- Oil wastes are discharged into the sea. As the tankers reach their destination they are emptied and filled with water to avoid floating too high. Before re-filling the dirty water is pumped out into the sea, thus polluting it. About 3 million tonnes of oil are discharged annually in this manner.
- The dirty water which accumulates in the bilge (basal flat part of the ship) transporting oil also add substantial amounts of oil in the water reaching upto a tune of 5 lakh tons per year.
- Oil tanker collisions often cause oil spills in the oceans. The famous Torrey Canyon Accident was responsible for 1,17,000 tons of Oil spilling in the British Channel.

- During loading and unloading millions of tons of oil are lost at the sites of port into the water annually.
- Petroleum refining is a combination of processes and operations designed to the crude oil into several fractions like motor gasoline, diesel fuel, heating oil, kerosene, jet fuel, bunker fuel, LPG, aviation gasoline and tractor fuel.
- The refining process releases- a lot of waste water as 20-70 litres of waste water is produced per litre of crude oil processed. The waste water contains acidic discharges as well as phenolic compounds of which chlorophenol, p-cresol etc. are more important which are often found to percolate deep and contaminate the ground water. If such waters are consumed, it may cause serious health problems like nervous disorders or even cancer.
- The oil refineries also cause air pollution. There are hydrocarbons, Sox, Nox, CO and SPM emissions from the refineries. Sulphur contents of the crude oil varies from 0.2 to 2.5%.
- The sulphur dioxide emissions are responsible for acid rains in the vicinity of the refineries. The Mathura Refinery has been responsible for the corrosion of the white marble of Taj Mahal, the greatest monument of cultural heritage of our country. The acidic emissions cause necrosis and chlorosis of the leaves and corrosion of materials. They also cause respiratory ailments and irritation of eyes and skin.

5.5. Natural Gas

Natural gas is one of the most important fuel resources in the world. The transportation of natural gas to multiple consumers started as early as in 1880 itself. Since the Second World War the expansion of the natural gas industry was spectacular throughout the world. Currently; the amount of natural gas depositions in the world are of the order of 80, 450 Gm^3. The best endowed country is the erstwhile Soviet Union with 40.0% of world reserves while the second is Iran with 14% of world's reserves, followed by USA (7%). Natural gas is primarily methane (CH_4). Like coal and oil, it is a fossil fuel. It was given off by decomposing plant and animal remains that were buried in the earth by sedimentary deposits for millions of years. That is why, natural gas deposits often accompany coal and oil deposits. Natural gas is the cleanest fossil fuel. It can be easily transported within the country by pipeline. It is used primarily for heating buildings, home cooking, industrial processes and generating electricity. (Sharma, 2018)

About 40% of the world's natural gas reserves are in CIS countries. Other countries with proven natural gas reserves are Iran (14%), United States (5%), Qatar (4%), Saudi Arabia (3%) and Nigeria (3%). Geologists expect to find more natural gas, especially in unexplored LDCs (less developed countries). Most of the natural gas reserves are located in same area as crude oil. (Sharma, 2018)

Presently we are passing through the peak period of fossil age. The fossil age may last for a few more decades, as the reserves are getting depleted very fast. Fig. 2 shows that the· fossil fuel age is likely to last from 1850 to 2850 and then all the reserves will be exhausted. (Sharma, 2018)

5.5.1. Composition of Natural Gas

At normal temperature and pressure, the contents of commercial natural gas are mainly methane (CH^4, ethane (C_2H_6) and varying amounts of propane (C_2H_8) and butane (C_4H_{10}). An average composition of natural gas indicates methane-83.0%, ethane 7.2%, propane-2.3%, butane-1.0%, N2-5.8%, CO_2- 0.2% etc. There may be traces of helium, oxygen, hydrogen and other substances. The main impurities are N_2, CO_2 and H_2S. If H_2S is more than 10 grains/m^3, it is removed commercially and converted to elemental sulphur by Clauss process. If concentration of H_2S is less, it is removed by the process called 'sweetening'. Natural gas containing H_2S is called 'SOUR GAS'. It has an unpleasant odour and H_2S dissolved in water follows a mild acid which is corrosive to pipes and valves. Some sources of natural gas contain helium upto 8% also. As such, natural gas is the main source of helium. (Sharma, 2018)

Table-4: Typical composition of Natural gas

Name	Formula	Volume (%)
Methane	CH_4	>85

Ethane	C_2H_6	3-8
Propane	C_3H_8	1-2
Butane	C_4H_{10}	<1
Pentane	C_5H_{12}	<1
Carbon Di oxide	CO_2	1-2
Hydrogen Sulfide	H_2S	<1
Nitrogen	N_2	1-5
Helium	He	<0.5

5.5.2 Origin of Natural Gas

According to one theory, when, earth was born, it was surrounded by methane, water, ammonia and hydrogen. Energy radiation from the sun and lightening discharges broke these simple compounds to a large number of organic compounds like 'amino acids' which form proteins, the 'stuff of life', In 1953, Nobel prize winner Harold C. Urey and Stanley Miller showed that electric discharge converts a mixture of methane, water, ammonia and hydrogen into complicated organic compounds that are responsible for making up living organisms. Thus methane generated in the final decay of dead organisms may well be the same substance from which the organism was derived. After the escape of hydrogen, oxidation of methane and breaking up of water, O_2 and N_2 remained in the earth's atmosphere. The methane is found most often, with or near the oil deposits, which indicates a major method of its formation. The gas could be considered to be the product of the microbial decomposition of organic matter in the absence of oxygen. The methane gas also escapes from decaying vegetation in swamp lakes mixed with little H_2S and CO_2, The gas also occurs in fire damps in coal mines creating explosion hazards. Methane is present in some gold and uranium mines of South Africa mixed with helium gas. Methane is also produced by the biological treatment of sewage or solid organic wastes under anaerobic conditions. These areas could be important sources of methane based on renewable resources. (Sharma, 2018).

5.5.3 Properties of Natural Gas

Since most of the natural gases contain methane over 90%, natural gas become synonymous to methane: It is the simplest form of hydrocarbon alkanes'. The melting point of methane is -183°C and its boiling point is -161.8°C. Natural gas can also be liquefied and Liquefied Natural Gas (LNG) is ideally transported across the sea in specially designed tankers. Density of LNG is 425.0 kg/m^3. The critical point of LNG is 82.1°C at 48.0 kg/cm^2. The atmospheric boiling point of LNG is -161.5°C. Comparative analysis of properties of methane and natural gas are discussed as follows:

The gross calorific value of natural gas is 1000 (k.cal/cu.m.), for methane it is 995 kcal/m^3. The net calorific value for natural gas is 902 kcal m^3 whereas for methane it is 859 kcal/m^3. The specific gravity of natural gas is 0.59 whereas for methane it is around 0.555. The stoichiometric air requirement (vol air/ vol gas) is. 9.6 for natural gas, whereas for methane it is 9.52. The inflammability limits for both the gases are 5-15% gas. The spontaneous ignition temperature for natural gas is 700°C. Methane is a colourless gas and less dense than water. Methane is a gas at ordinary temperature, slightly soluble in water, but highly soluble in organic liquids like gasoline under ultraviolet rays or at 250-400°C, methane and chlorine combine to yield HCI and CH_3Cl called chloromethane or methyl chloride. This is called chlorination which may lead to the formation of CH_2Cl_2 (dichloromethane or methylene chloride), $CHCl_3$ (trichloromethane or chloroform) and CCl_4 (tetra chloromethane or carbon tetrachloride). Methane reacts with fluorine even in the dark at room temperatures. Methane affects skin, throat and lungs. Being malodorous it presents an unpleasant atmosphere. It retards the growth of vegetation. (Sharma, 2018)

5.5.4 Sources of Natural Gas

There are mainly two sources of natural gas. It occurs in gas fields i.e. underground reservoirs similar to oil reserves and is recovered by drilling gas wells. In addition, large quantities of gas are produced in association with the production of crude oil. Oil normally contains alkanes from methane upwards. In the reservoir the lower gases are in solution from under considerable pressure. When the oil is brought to the surface, the pressure is released forming associated gas. In some oil fields, particularly those in inaccessible regions, this gas is burnt. In other fields it is collected and used. Composition of a typical associated gas is 76% CH_4; 11.4% C_2H_6; 5.3% C_3H_8; 2.2% C_4H_{10}; 1.3% C_5H_{12}; 2.3% CO_2 and 0.3% H_2S.

Synthetic natural gas, a mixture of carbon monoxide and hydrogen is an ideal connecting link between a source of fossil fuel and substituted natural gas. The low grade coal is initially transformed into synthetic gas ($CO+H_2$) by gasification process followed by catalytic conversion to methane. The substituted natural gas can be used as a fuel or as a feed back stock for chemical and allied industry.

Natural gas is used in many ways. The global consumption of energy in the form of natural gas is presently equal to one half of the consumption of energy in the form of petroleum. Natural gas is used in energy sector, in gas turbines and in diesel engines. Natural gas is also used in the compressed form for road transport. It is the main energy resource in chemical and fertilizer industries. Natural gas is used extensively in petrochemical, metallurgical and sponge iron manufacturing units.

5.6. Summary

- ***Fossil fuels are derived from plant and animal remains buried in the earth millions of years ago. Fossil fuels i.e. Coal, petroleum and natural gas provide 85-90% of energy demand of the modern world.***
- ***Coal is of three types – Anthracite (with maximum carbon and energy), bituminous and lignite.***
- ***Coal is processed by different techniques like coal gasification to produce gas that burns as cleanly as natural gas.***
- ***Coal liquification is done to produce a thick, oily substance. Petroleum is most widely used fossil fuel. It is also obtained from oil shales, which is a sedimentary rock and tar sands. On fractional distillation petroleum yields a large variety of substances.***
- ***Natural gas, mainly comprising methane is the cleanest fossil fuel. While fossil fuels are the backbone of development and economy, they are also***

major sources of environmental pollution. Burning of coal results in gaseous emissions including SOx and NOx, SPM and heavy metals.

- ***Oil spills causes Marine pollution and harm to marine biology. Mining of these fossil fuels also result in large scale degradation of land and ecology. This unit covers the important renewable energy resources – tidal, wind, hydropower and geothermal etc.***

TERMINAL QUESTIONS

1. (a) Fill in the blank spaces with appropriate words.

………. is hard, black, lustrous, shiny and dense coal. It is the highest grade coal with calorific value of 8,250 to 8,700 kcal/kg, it contains 86-98% of carbon content. In anthracite coal the volatile matter is low being just 2-14%. It is not found in India, however, low amount available in State……… …….. ……….. It is mainly found in UK, USA and Australia. India imported Anthracite coal from………... Bituminous is also called ……….and high grade coal next to anthracite. It has a calorific value in the range of………………. It contains about 46-86% carbon. It is found in India in the region of…………., Jharkhand and Orissa. ………. is also called Brown coal. It is inferior quality, low grade coal. It has laminar (banded) structure with woody, fibrous, brownish black appearance, resembling wood, hence the name. In Latin, Lignum means……….. Calorific value of lignite coal is about 6,150 to 7,300 kcal/kg. It has a moisture content of about 30-50% before exposure to air. Its volatile matter is about 30%. Due to high moisture, rapid oxidation and low heating value, it is not economical to transport it to distant places.

2. (a) Define the hydropower.
2. (b) What do you understand by dams? Explain important dams of India.
3. (a) What are the advantages and disadvantages of hydropower?
   (b) What is coal? Describe the types of coal.
4. a) What is the properties of coal? Explain in brief
5. (a) Describe the coal production and processing.
6. (a) Fill the blank spaces with appropriate words.

India has a large hydro power potential totaling about…….., which can be used. However, 75% of it is concentrated in the……….., which is tectonically very unstable. The history of hydropower generation in India is more than……. ……. ……. The first-hydropower station in India was a small hydropower station of 130 KW commissioned in …….. at near Darjeeling in West-Bengal. Subsequently, many small hydropower stations were set up. With the advancement in technologies and increasing requirement of electricity, emphasis was shifted to large sized hydropower stations. The growth of hydropower in the country since 1990 to 2000 is shown in Fig 1.6. This hydropower capacity is about 25 percent of the total installed capacity for electricity generation. ……….. ….. …………in the Government of India is responsible for the development of large hydropower projects in India.

6. (b) Capacity wise Largest Hydropower project of World is (Tehri Dam/Three George Dam/Hirakund dam/Long tam Dam)

(c) Which coal is known as hard coal? (Anthracite/Lignite/Peat/Bituminous)

(d) Highest moisture content is found in (**Peat**/ Lignite/Peat/Bituminous)

(e) What do you understand oil? Write the environmental impacts of oil.

7. (a) what is natural gas? Explain the composition of Natural gas

(b) Describe the properties and sources of Natural Gas.

ANSWERS

1 (a) anthracite coal, Jammu and Kashmir, Australia, Soft coal, 7,500 to 8,700 kcal/kg, West Bengal, Lignite, wood,
2 (a) see section 5.2.
(b) See section 5.2 and 5.2.3
3 (a) See section 5.2.4.
(b) See section 5.3. and 5.3.1
4 (a) See section 5.3.2
5 (a) See the section 5.3.2 under heading production and processing of coal
6 (a) 1,48,700 MW, Himalayan region, 100 years old, 1897, Sidrapong, Ministry of Power
(b) Three Georges Dam
(c) Anthracite
(d) Peat
(e) See the section 5.4 and 5.4.1

7 (a) See the section 5.5 and 5.5.1
(b) See the section 5.5.3 and 5.5.4

Reference

1. Sharma, P.D. (2018). Text book on Ecology and Environment 13th edition. ISBN: 978-93-5078-122-7.
2. Energy statistics (2017). Central statistics office. Ministry of statistical and Programme Implementation, India.

UNIT-6: NON-CONVENTIONAL ENERGY SOURCES I: SOLAR, WIND, TIDAL (OCEAN), WAVE (WATER)

Unit Structure

6.0. Learning Objectives

After studying this unit you will be able to understand:

- What is Non-conventional energy?
- Meaning, status, advantages and disadvantages of solar energy
- Meaning, status, advantages and disadvantages of Wind energy
- Meaning, status, advantages and disadvantages of Tidal energy
- Meaning, status, advantages and disadvantages of wave (water) energy

6.1. Introduction

Without energy we cannot perform any work. There are various forms of energy on this planet and human being used these energy sources since time immemorial. The earth is rapidly running out of conventional fuels. Non-conventional sources of energy are becoming our upcoming future. These non-conventional sources of energy are generally pollution free and available in sufficient amount. As you know human being used conventional energy sources (fossils fuel, petroleum, coal). These conventional sources of energy declining rapidly therefore, the whole world looking for the alternative sources of energy. Natural resources like winds, tides, solar, biomass, etc generate energy which is known as "Non-conventional energy resources". These energy resources are pollution free and hence we can use these to produce a clean form of energy.

As the consumption of energy rapidly increasing, the human population relies more on fossil fuels such as coal, oil and gas. There is critical requirement to preserve the energy supply for future since the prices of oil keep rising day by day. Therefore, we need to use more and more renewable sources (Non-conventional energy sources) of energy. For the efficient utilization of non-conventional sources, there has been an establishment of a separate department namely **"Department of non-conventional sources of energy"** by the Government of India. Basically, renewable resources provide energy in four important areas like **electricity generation, water heating or cooling, transporting and rural**. In this unit you will learn about the non-conventional energy sources such as solar, wind, tidal and wave (water).

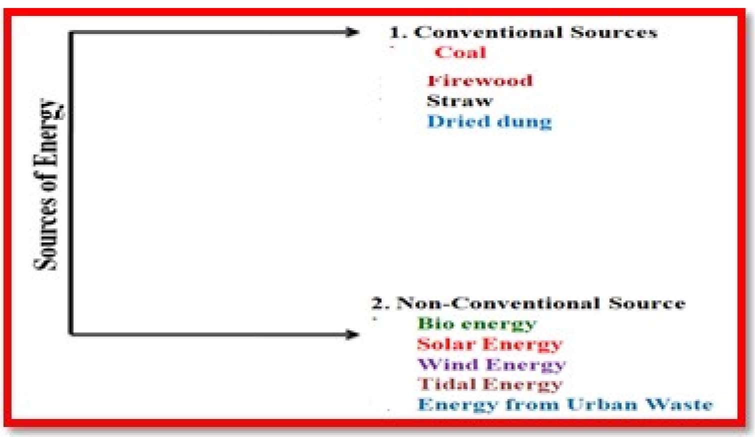

Figure 1: Examples of Conventional and Non-Conventional energy

6.2. Meaning of Non-Conventional energy

Energy is the capacity or ability to work vigorously. It has a significant role to play in our day to day life, in fact, it is most important and required in every sector of development. It is used in household, industry, communication, transport, defense or agriculture. Energy resources are broadly classified as **Conventional** and **Non-conventional** sources of energy. Conventional sources of energy are not available in the environment in more quantity, however there uses are unlimited. These conventional energy sources are called as non-renewable energy sources.

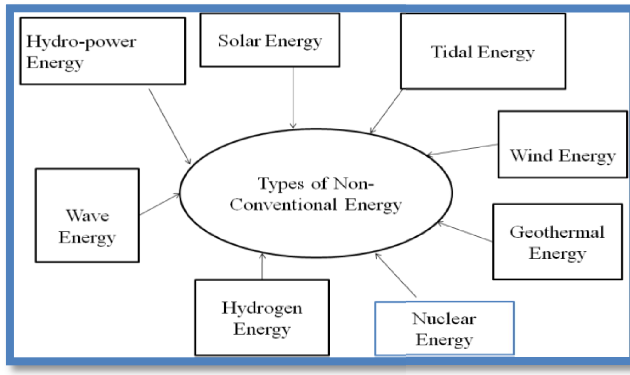

Figure 2: Types of Non-Conventional Energy

There are various types of Non-conventional sources of energy such as solar energy, wind energy, tidal energy, geothermal energy, wave energy, Biomass etc.

Non-conventional energy sources are also called renewable sources of energy. The common examples of non-conventional energy are bio-energy, solar energy, wind energy and tidal energy. Government of India has established a separate Department under the Ministry of Energy called as the Department of Non-conventional Energy Sources for efficient use of non-conventional energy.

6.3. Solar energy

Solar power or solar energy is generated by converting solar energy directly into electrical energy. Solar energy or solar power is an essential energy of all non-conventional energy sources. Unfortunately, usable amount of solar energy is very less. It is basically energy of Sun and the most important non-conventional source of energy. It is non-polluting, environment-friendly and is available in sufficient quantity. Solar energy is radiant light and heat from the Sun that is connected using a range of technologies. These technologies are solar heating, photovoltics, polar thermal energy etc. Solar energy is an important source of renewable energy and its technologies are mainly divided into two categories i.e.

passive solar and active solar. Passive solar techniques comprise orienting a building to the Sun, selecting materials with favorable thermal mass or light-dispersing properties, and designing spaces that naturally circulate air. Active solar techniques comprise the use of photovoltaic systems, solar-water heating.

6.3.1. Status of Solar energy in India

As you know that the India lies in the sunny belt of the globe. India is endowed with huge solar energy potential. India gets 300 days of sunshine a year. About 5,000 trillion kWh per year energy is incident over Indian land area with most area receiving 4-7 kWh per sq. meter per day. Hence, both technology solar thermal and solar photovoltaic's can effectively provide huge capability for solar power in country. It can be observed that highest annual global radiation is received in Rajasthan and northern Gujarat.

Table-1: Some solar plants in India (Ministry of New and Renewable energy, 2017)

S.N.	Name of Plant	State	Peak Power (in MW)	Commission Year
1.	Charanka Solar Park, Charanka Village, Patan	Gujarat	224	April, 2012
2.	Welspun Solar MP Project, Neemuch	Madhya Pradesh	151	March, 2013
3.	Mahagenco Solar Project	Maharastra	130	March, 2013
4.	Rajgarh Solar PV (NTPC), Rajgarh	Madhya Pradesh	50	March, 2014
5.	Welspun Energy Rajasthan Solar Project, Phalodhi	Rajasthan	50	March, 2013
6.	Telcher Kaniha Solar PV (NTPC)	Odisha	10	March, 2014
7.	Unchahar Solar PV (NTPC), Unchahar	Uttar Pradesh	10	March, 2014

Table-2: Current solar power capacity in some states of India (Ministry of New and Renewable energy, 2017)

S.N	Name of State or Union territory	Capacity (in MW)
1.	Rajasthan	1199.7
2.	Gujarat	1000.05
3.	Madhya Pradesh	673.58
4.	Maharashtra	378.7
5.	Andhra Pradesh	279.44
6.	Punjab	200.32
7.	Tamil Nadu	157.98

8.	Karnataka	104.22
9.	Chattisgarh	73.18
10.	Telangana	72.25
11.	Uttar Pradesh	71.26
12.	Jharkhand	16
13.	Haryana	12.8
14.	West Bengal	7.21
15.	Delhi	6.71
16.	Andaman & Nicobar	5.1
17.	Tripura	5
18.	Uttarakhand	5
19.	Daman and Diu	2.5
20.	Lakshadweep	0.75

Solar mission: Jawaharlal Nehru National Solar Mission (JNNSM) was launched on 11th January, 2009. The target of JNNSM for Grid Connected Solar Projects is about 20,000 MW by 2022. The JNNSM had adopted a three-phase approach viz. first four year (2009-13) had marked as Phase-I, remaining 4 years of the twelfth Plan (2013–17) had been marked as Phase-II and the thirteenth Plan (2017–22) will be Phase-III of the project. The aim of this project was to add 1,000 MW of grid solar power by 2013, and another 3,000 MW by 2017. The target for 2017 may be higher based on the availability of international funds and technology transfer.

However, in June 2015 The Union Cabinet of India gave approval for stepping up of India's solar power capacity goal under the JNNSM by five times, reaching 100 GW by 2022. The target will comprise of 40 GW rooftop and 57 GW through large and medium scale grid connected solar power plants. Through this step of GOI will become one of the greatest countries of the world in solar energy power generation. (**Ministry of New and Renewable energy, 2017**)

Solar power in India is a one of the fastest developing industries. Solar installed capacity of India reached 28.18 GW as of 31 March 2019. The Indian government had an initial target of 20 GW capacities for 2022, which was achieved four years ahead of schedule. In 2015 the target was raised to 100 GW of solar capacity by 2022, targeting an investment of US$100 billion. India expanded its solar-generation capacity 8 times from 2,650 MW on 26

May 2014 to over 20 GW as on 31 January 2018. India added 3 GW of solar capacity in 2015-2016, 5 GW in 2016-2017 and over 10 GW in 2017-2018. (**Ministry of New and Renewable energy, 2017**)

Table-3: State wise Estimated Solar Power Potential: (Source: Ministry of New and Renewable Energy Solar R&D Division, 2016)

State	Solar potential (MW)
Rajasthan	142.31
Jammu & Kashmir	111.05
Maharashtra	64.32
Madhya Pradesh	61.66
Andhra Pradesh	38.44
Gujarat	35.77
Himachal Pradesh	33.84
Orissa	25.78
Karnataka	24.70
Uttar Pradesh	22.83
Telangana	20.41
Chhattisgarh	18.27
Jharkhand	18.18
Tamil Nadu	17.67
Uttarakhand	16.80
Assam	13.76
Bihar	11.20
Manipur	10.63
Mizoram	9.09
Arunachal Pradesh	8.65
Nagaland	7.29
Kerala	6.11
Meghalaya	5.86
Sikkim	4.94
Haryana	4.56
Punjab	2.81
Tripura	2.08
Delhi	2.05
Goa	0.88
TOTAL	741.94

6.3.2. Uses of Solar energy

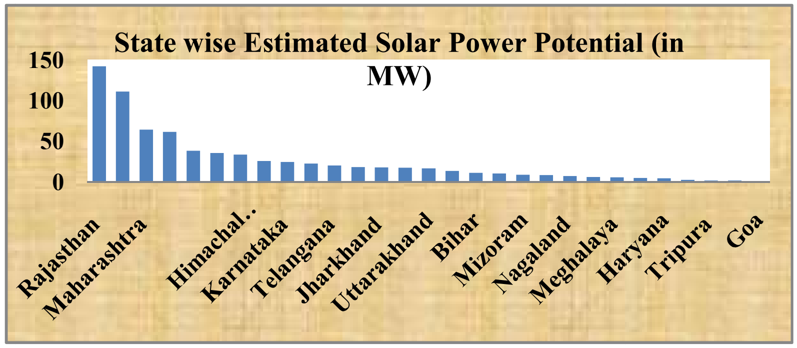

Figure 3: Statewise solar power potential in India

Uses of Solar energy: Solar energy is being used since time immemorial. The solar energy used for drying the food, agricultural products etc. However, in modern context the various uses of solar energy are discussed below:

- Solar cooker directs the solar heat into the secondary reflector inside the kitchen, which emphasizes the heat to the bottom of the cooking vessel. It has a covering of a glass plate. These are applicable widely in developing countries. It helps to reduce the deforestation.
- Solar heaters use solar energy to heat water.
- Solar cells also use solar power to generate electricity from the sun energy.

Types of Solar Energy

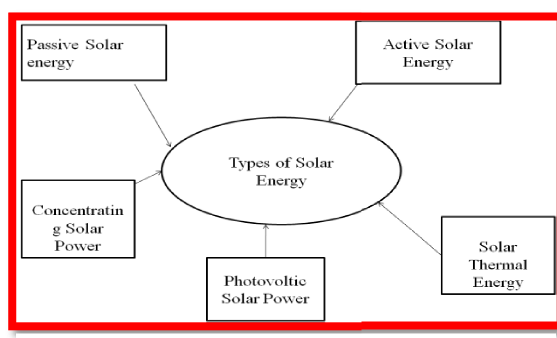

Figure 4: Types of Solar Energy

- Solar energy can be classified into two categories. **Passive solar energy** and **active solar energy** belongs to the mode of conversion and solar thermal energy, photovoltaic solar power and concentrating solar power. There are various types of solar energy which are given below:
- **Passive solar energy:** This refers to trapping sun's energy without using any mechanical devices.

- **Active solar energy:** This uses mechanical devices to collect, store and distribute the energy.
- **Solar thermal energy:** This is the energy attained by converting solar energy into heat.
- **Photovoltaic solar power:** This is the energy obtained by converting solar energy into electricity.
- **Concentrating solar power:** This is a type of solar thermal energy which is used to generate solar power electricity.

6.3.3. Advantages and disadvantages of Solar energy

There are several advantages as well as disadvantages of solar energy which are summarized in Fig-4 and 5 and also described below:

Advantages of Solar Energy: The advantages of solar energy are given below:

Solar energy is clean: Solar energy is regarded to the cleanest form of energy. As there is no emission of CO_2 (main contributor of global warming). Hence, solar energy reduces the global warming. As you know that global warming is increase in the average temperature of earth. As Solar energy does not produces any CO_2 during electricity generation and reduces concentration of CO_2 in atmosphere.

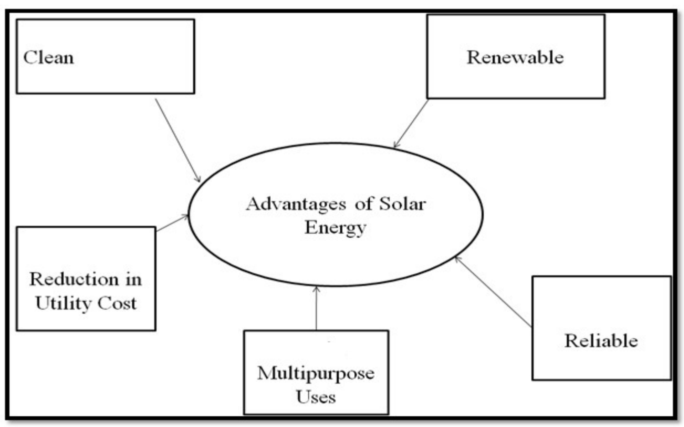

Figure 5: Advantages of Solar Energy

Solar energy is renewable: There is sufficient amount of energy accessible on earth as long as the sun exists. Among all the advantages of solar panels, most important aspect is that solar energy is a really renewable energy source. Solar energy will be available as long as we have the sun.

It is reliable: The energy can be stored in the batteries and so there is no question of unreliability.

Reduction in utility costs: When we will use solar energy our electricity bills will also reduced. Moreover, not only will we be saving on the electricity bill, there is also a possibility to receive money for the extra energy that we export back to the grid.

It is Multipurpose: Solar energy can be used for diverse purposes. It can be used to produce electricity in areas without access to the energy grid, to distill water in regions with limited clean water supplies and to power satellites in space. Solar energy can also be included into the materials used for buildings.

Disadvantages of Solar energy: There are few disadvantages of solar energy which are given below:

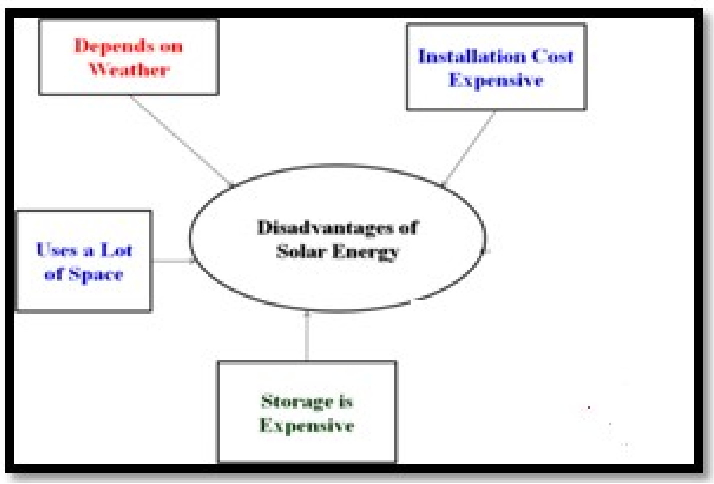

Figure 6: Disadvantages of Solar Energy

1. **It Depends on Weather:** As you know that solar energy is depends on sun therefore, the production of solar energy is low during winters or during cloudy days. Solar panels are dependent on sunlight to effectively collect solar energy. Therefore, a few cloudy, rainy days can have a noticeable effect on the energy production. It is also taking into account that solar power cannot be generated during the night.

2. **Expensive:** Installation cost of solar panel is expensive. The initial cost of purchasing a solar system is quite high. This includes paying for solar panels, inverter, batteries, wiring, and for the installation. Batteries, used in off-the-grid solar systems, can be charged during the day so that the energy is used at night. This is a good solution for using solar energy all day long but it is also quite expensive.

3. **Uses a Lot of Space:** The solar panel need a lot of space and some roofs are not big enough to fit the numbers of solar panels. An option is to install few panels in yard but they need to have access to sunlight.
4. **Pollution:** Although pollution related to solar energy systems is far less compared to other sources of energy, solar energy can be related with pollution. Transportation and installation of solar systems have been associated with the emission of greenhouse gases (GHG). There are also some toxic materials and hazardous products used during the manufacturing process of solar photovoltaic systems. Disposal of the photovoltaic equipments can cause harm to the nature and environment.

6.4. Wind energy

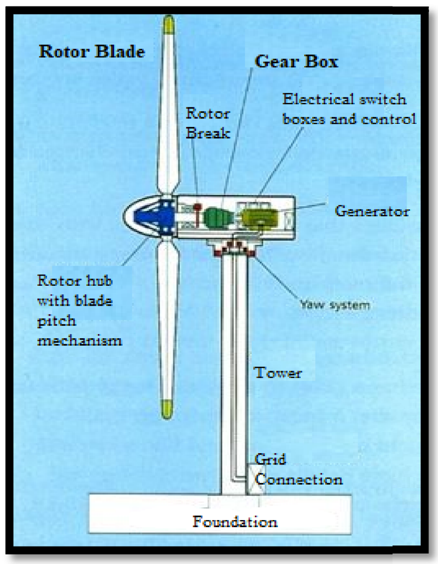

Figure 7: Wind turbine

As you know wind is the horizontal motion of the air. Wind is also source of energy. Wind energy or wind power describes the process by which wind is used to generate electricity. Wind turbines use wind to make electricity. **Wind power** is the use flow of air through wind turbine to provide the mechanical power to turn electric generators. Wind energy supplies variable power, which is very consistent from year to year but has significant variation over shorter period of time. In this mechanism wind turbine works opposite to fan. The principle of wind turbine in which energy in the wind turns two or three propellers like blade around rotor. The rotor is connected to main shaft which spins a generator to produce electricity. At 100 feet or more above ground, they can take advantage of faster and less turbulent wind.

Table: 4- Top wind power producing countries (MNRE, 2017)

Country	Wind-power Production (TWh)
US	190.7
China	185.8
Germany	78.9
Spain	48.1
India	42.8
United Kingdom	40.3
Canada	26.2

Brazil	21.6
France	21.2
Sweden	16.3
(rest of world)	161.7
World Total wind power	**833.6**

6.4.1. Status of Wind energy in India

India has the fourth largest installed capacity in wind power after China, United States and Germany. The total installed capacity of wind power in India is about 32 GW. Wind Energy has spread across the Southern, Western and Northern parts of country. The potential of wind energy is concentrated in the states **of Andhra Pradesh, Gujarat, Karnataka, Madhya Pradesh, Maharashtra, Rajasthan, Tamil Nadu and Telangana**. **Tamil Nadu** has the highest installed capacity in the India with around **7.5 GW.** Climatic factors of Tamil Nadu are very much favourable to wind power development. **Maharashtra** has the second highest installed capacity of about **5 GW** followed by **Gujarat** with third highest installed capacity of about **4 GW** in the country. India's largest windmill farms is in **Kanyakumari** which generates **380MW** of electricity. **(Sharma, 2018)**

Table:5- Installed wind capacity in different states of India (Sharma, 2018)

State	**Total Capacity (MW)**
Tamil Nadu	8,197
Gujarat	5,613
Maharashtra	4,784
Karnataka	4,509
Rajasthan	4,298
Andhra Pradesh	3,963
Madhya Pradesh	2,520
Telangana	101
Kerala	53
Others	4
Total	34,043

In India, Tamil Nadu wind power capacity is around 29%. At present time, Tamil Nadu has become a leader in Wind Power in India. In Muppandal windfarm, Tamil Nadu the total capacity is 1500 MW, the largest wind power plant in India. The total wind installed capacity in Tamil Nadu is 7633 MW. Maharashtra is one of the prominent states that installed wind power projects second to Tamil Nadu in India. Now there are 50 developers registered with state nodal agency "Maharashtra energy Development Agency" for development of wind power projects. All the major developers of wind turbines including Suzlon, Vestas, Gamesa, Regen, Leitner Shriram are active in Maharashtra. **(Ministry of New and Renewable Energy, 2017)**

Government of Gujarat has been focusing on renewable energy which has led to sharp rise in the wind power capacity in the last few years. ONGC Ltd. has installed a 51MW wind energy farm at Bhuj in Gujarat. In consideration of unique concept, Government of Madhya Pradesh has sanctioned another 15 MW project to Madhya Pradesh Windfarms Ltd. MPWL, Bhopal at Nagda Hills near Dewas under consultation from Consolidated Energy Consultants Ltd. CECL Bhopal. In Kerala 55 MW production of wind power is also installed. The first wind farm of the state was set up 1997 at Kanjikode in Palakkad district. Current installation capacity stands at 2.0 MW. Odisha has a windpower potential of 1700MW. Some parts of Jammu & Kashmir (Kargil and Ladakh) have wind energy potential. These areas of J& K are yet to be utilized (**Ministry of New and Renewable Energy, 2017)**

6.4.2. Uses of wind energy

There are various uses of wind energy which are given below:

1. **Wind Power Generation:** Wind energy is used for wind power generation. In this process, a wind turbine is used to harness the energy of the wind. As the wind starts to move the turbine blades, a generator starts to turn which then produces electricity.
2. **Transportation:** Another use of wind energy is in transportation. Civilizations have for many thousands of years used wind energy in transportation in the form of sailing. In more recent times we have seen both small and large ships capable of sailing under the power of the wind. You may surprise to know that some modern shipping companies are beginning to embrace wind energy as a use in transportation. Vessel’s including fishing trawlers and even cargo ships have had large kites installed that are capable of helping to reduce fuel consumption on long journey’s by as much as 30% under the right conditions. This is an obvious attraction for companies that spend significant amounts on fuel and for those looking to reduce their carbon footprint.

3. **Wind Sports & Activities:** A more enjoyable use of wind energy is for sports and activities that rely on wind energy.
4. **Food Production:** Wind energy has traditionally been used for food production purposes through the use of windmills. Before the industrial revolution, these structures were widely used for milling grain so that it could be then used for producing food such as bread.
5. **Pumping Water:** Wind pumps are similar to a traditional windmill but instead of milling grain, they can also pump water. These structures were historically used for draining land. However, these wind pumps have been replaced due to the introduction of electrical motors.

6.4.3. Advantages and disadvantages of Wind energy

There are several advantages and disadvantages of wind energy which are summarized in Fig-8 and Fig-9 and also described below:

Advantages of Wind energy:

1. It is renewable & sustainable: Wind energy is both renewable and sustainable. The wind will never run out, unlike reserves of fossil fuels (such as coal, oil, and gas.) This makes it a good choice of energy for a sustainable power supply. We should look utilized wind energy for sustainable development.

2.

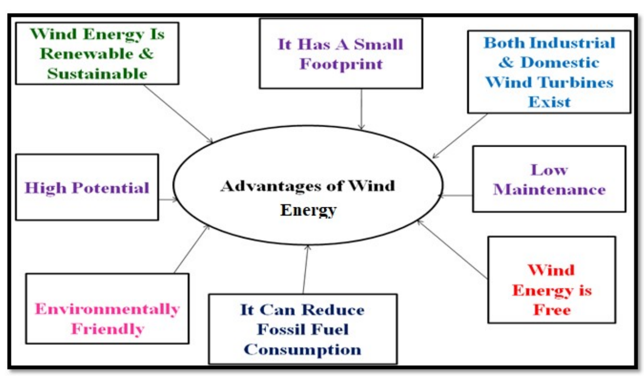

Figure 8: Advantages of wind energy

2. It is environmentally friendly: Wind energy is also one of the most environmentally friendly energy sources available in present time. The simple reason is that wind turbines don't create pollution during electricity generation. Most non-renewable energy sources need to be burnt. This process releases certain harmful gases such as CO_2, CH_4 into the ambient environment. These gases are known to contribute to

climate change and global warming. On the other hand, wind turbines produce no greenhouse gases.

3. It can reduce fossil fuel consumption: Wind energy reduces the need to burn fossil fuel alternatives such as coal, oil, and gas. This can help to conserve dwindling supplies of the natural resources on earth. As a consequence, they will last longer and help to support future generations.

4. It is Free: If we compare wind energy with other non-renewable energy sources we will find that the wind energy is completely free. Everyone can make use of the wind and it will never run out. This makes wind power a feasible alternative for generating cheap electricity.

5. It has a small footprint: Wind turbines have a comparatively small land footprint. Although they can tower high above the ground, the impact on the land at the base is minimal. Wind turbines are often constructed in fields, on hills or out at sea. At these locations, they pose hardly any inconvenience to the surrounding land. Farmers may also use their fields, livestock can still graze the hills and fishermen can still able to fishing.

7. It may be used in remote locations: Wind turbines can play a important role in helping to bring power to remote areas. This may help to benefit everything from small off-grid villages to remote research facilities. It might be impractical or too expensive to hook such remote areas up to traditional electricity supplies. In these cases, wind turbines could have the solution. Wind turbines may be used to generate power in such areas.

8. It is cheaper: The first wind turbine of world started generating electricity in 1888. Since, wind energy have become more efficient and have come down in price. Therefore, wind power is becoming much more reachable. Government subsidies are also helpful to minimize the prizes of the wind technologies. Many nations of the world now provide incentives for the construction of wind turbines.

9. Low maintenance: The wind turbines require low maintenance charges. New wind turbines can last a long time prior to it requiring any maintenance. Although, older turbines can come up against reliability issues, technological advancements are helping to improve overall reliability.

10. Low running costs: As you know wind energy is free, running costs are also generally low. The only ongoing cost of wind energy is for the maintenance of wind turbines, but in above point it also explicitly cleared that maintenance of wind turbines required minimum costs.

11. High Potential: Wind energy has huge potential, as it is both renewable and sustainable and is present in a wide variety of locations. Although wind turbines aren't cost-effective at every areas the technology is not limited to just a handful of locations. This is an issue that can affect other renewable energy technologies for example geothermal power plants.

Disadvantages of Wind Energy: There are few disadvantages of wind energy which are given below:

1. Wind fluctuation: Wind fluctuation is one of the main disadvantages of wind energy. This can cause problems for wind farm developers. Developers often spend a high amount of time and expenditure in investigating whether a specific site is suitable for wind power generation.

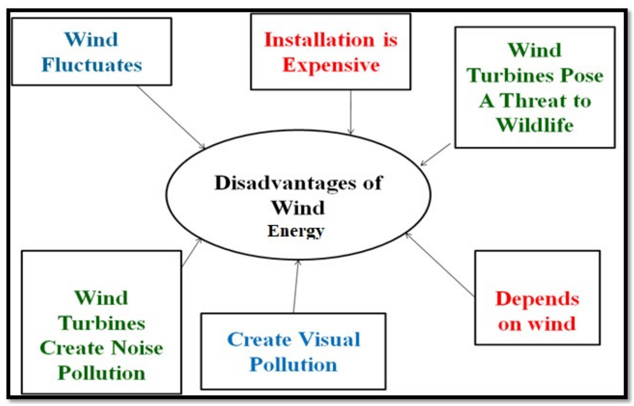

Figure 9: Disadvantages of wind

2. Expensive installation: However, the costs of installation of wind turbines are reducing over time. But, wind turbines are still expensive. At the starting of the installation, an engineer should take out a site survey. This may involve having to erect a sample turbine to measure wind speeds over a period of time. If deemed sufficient, a wind turbine then needs to be manufactured, transported and erected on top of a pre-built foundation. All of these processes can rise the expenditure during installation

3. Threat to wildlife: Wind turbines pose a threat to wildlife. These turbines are specially harmful to birds and bats. However, scientists now believe that turbines create less of a threat to wildlife than other anthropogenic structures. Other installations such as cell phone

masts and radio towers are far more dangerous to birds than wind turbines. However, wind turbines still cause high to mortality rates among bird and bat populations.

4. Create noise pollution: It is one of the most common disadvantages of wind turbines. You can frequently hear a single wind turbine from hundreds of meters away. Combine multiple wind turbines with the right wind direction and the audible effects can be much greater. Noise pollution from wind turbines has ruined the lives of many communities.

5. Create visual pollution: Another common disadvantage of wind turbines is the visual pollution. Although many people actually like the look of wind turbines, others don't.

6.5. Tidal Energy

Tidal power is a type of hydropower that converts the energy of tides into electricity. In areas where the sea experiences waves and tides, electricity van be generated by using tidal power. India may take up **"ocean thermal level conversion"** by which it will be able to generate **50,000MW** of electricity to meet the power requirements.

Tidal energy is taken from the oceanic tides of earth near ocean. **Tidal forces** are periodic variations in gravitational attraction exerted by celestial bodies. These forces create corresponding motions in the oceans. Due to the strong attraction to the oceans, a bulge in the sea level is produced, causing a momentary increase in sea level. When the Earth rotates, this bulge of sea water meets the shallow water adjacent to the shoreline and creates a **tide**. This occurrence takes place in an reliable manner, due to the constant pattern of the moon's orbit around the earth. The magnitude and character of this motion reflects the changing positions of the Moon and Sun relative to the Earth, the effects of rotation of earth, and local geography of the sea floor and coastlines..

Energy generation through tides is the only technology that draws on energy inherent in the orbital characteristics of the Earth-Moon system. Other natural energies exploited by human technology originate directly or indirectly with the Sun, including fossil fuel, conventional hydroelectric, wind biofuel, wave and solar energy.

As you know burden on conventional energy sources increasing day by day, and tidal energy has potential for future electricity generation. Tides is sea are more predictable than the wind and sun. Among sources of renewable energy, tidal energy has traditionally suffered from relatively high cost and limited availability of sites with sufficiently high tidal ranges or flow velocities, thus constricting its total availability.

The world's first large-scale tidal power plant of world was the **Rance Tidal Power Station, France**, which became operational in **1966**. It was the largest tidal power station in terms of output until **Sihwa Lake Tidal Power Station** opened in **South Korea** in August 2011 **(Ministry of New and Renewable Energy, 2017)**

6.5.1. Status of Tidal Energy in India

India is surrounded by sea from three sides; therefore, India has great tidal energy potential. The possible operating tidal power plants in India are Kutch and Cambay.

Table 6: Possible operating tidal power plants in India (Ministry of New and Renewable Energy, 2017)

Place	Mean Tidal Range (mm)	Area of Basin (km^2)	Maximum capacity (MW)
Kutch	5.3	170	900
Cambay	6.8	1970	7000

The Gujarat government is all set to develop India's first tidal energy plant. The state government has approved Rs 25 crore for setting up the 50 MW plant at the Gulf of Kutch. It will produce energy from the ocean tides.

The state government signed a MoU with Atlantis Resource Corporation in 2017 to develop the plant. "The proposal was approved in this year's budget session," says Rajkumar Raisinghani, senior executive with **Gujarat Power Corporation Limited (GPCL).** Atlantis Resource Corporation is a UK-based developer of tidal current turbines. "The equipment has been imported and work will start anytime soon. We are awaiting Coastal Regulation Zone clearance from Ministry of Environment and Forests, which is expected soon," told by Raisinghani.

According to the GPCL officials, if this 50 MW plant is successfully commissioned, its capacity will be increased to about 200 MW. As per a study conducted by Atlantis Resource Corporation and the state government two years ago, the Gulf of Kutch has a total potential of approximately 300 MW. The biggest operating tidal station in the world, La Rance in France, generates 240 MW. According to the estimates of the Indian government, the country has a potential of approximately 8,000 MW of tidal energy. This includes about 7,000 MW in the Gulf of Cambay in Gujarat, about 900 MW in the Gulf of Kutch and about 100 MW in the Gangetic delta in the Sunderbans region of West Bengal **(Ministry of New and Renewable Energy, 2017).**

However, despite the huge potential unfortunately, India has no policy on tidal energy. "A clear policy is very important for developers to have clarity on tariff and commercial development of tidal energy in the country," says **Aditya Venketesh, executive director, Urja Global Limited**. The government must also provide subsidy to reduce the cost of importing wave technology so that consumers can get the cheapest rate on per unit consumption. The government of Gujarat last year approved 10 MW tidal energy plant proposed by Urja Global Limited in association with a US-based company Ocean Energy Industries. But still no date has been given for starting the project yet. "The Ministry of New and Renewable Energy should prepare a proper policy on tidal energy since the development of this sector is primarily their responsibility," says an official of the GPCL.

6.5.2. Uses of Tidal Energy

Tidal Energy is one of the many forms of renewable energy like solar, wind and geothermal Energy. Tidal Energy is derived from the movement of tides due to the gravitational attraction of the Earth and the Moon. Tidal Energy is a form of Gravitational Energy which can be used to do Work or be converted in other forms of Energy. Tidal Energy is still an immature technology with advancements in Tidal Energy not as rapid as other forms of Renewable Energy. On the other hand, Tidal Barrages is a mature technology through its development too has been slow because of high investment and long building time. The tidal energy may useful for following given purposes.

Tidal Electricity: Like other forms of Energy, the main usage of Tidal Energy is in the generation of Electricity. Tidal Energy is being used in France to generate 240 MW of Tidal Electricity at very low costs. There are other smaller plants in operation in Canada, China and Korea as well. Tidal Energy is reliable as Tides are uniform and predictable in nature.

Grain Mills : Tidal Energy has been used for hundreds of years. Just like Wind Mills, Tidal Energy was used for the mechanical crushing of grains in grain mills. The movement of

Turbines due to Tidal Energy was used in the crush Grains. However, with the start of Fossil Fuels, this usage of Tidal Energy for this purpose has become quite low.

<u>**Energy Storage**</u> : Tidal Energy can also be used as a store of energy. Like many of the hydroelectric dams which can be used a large energy storage, therefore, tidal barrages with their reservoirs can be modified to store energy. Though this has not been tried out, with suitable modifications Tidal Energy can be stored as well though costs may prove to be high.

<u>**Provide Protection to coast during storms**</u> : Tidal Barrages can prevent Damage to the Coast during High Storms and also provide an easy transport method between the 2 arms of a Bay or an Estuary on which it is developed.

6.5.3. Advantages and disadvantages of tidal energy

There are various advantages and disadvantages of tidal energy which are summarized in fig-10 and Fig-11 and also discussed below:

<u>1. It is renewable:</u> Tidal energy's source is a result of the effects of the sun and moon's gravitational fields, combined with our planet's rotation around its axis, which result in low and high tides. Therefore, the power source of tidal energy is potentially renewable, whether we are talking about tidal barrages, stream generators or the more recent technology, dynamic tidal power. If we compare to nuclear reserves and fossil fuels, the sun and moon's gravitational fields, as well as the rotation of earth around its axis, will not end to exist any time soon.

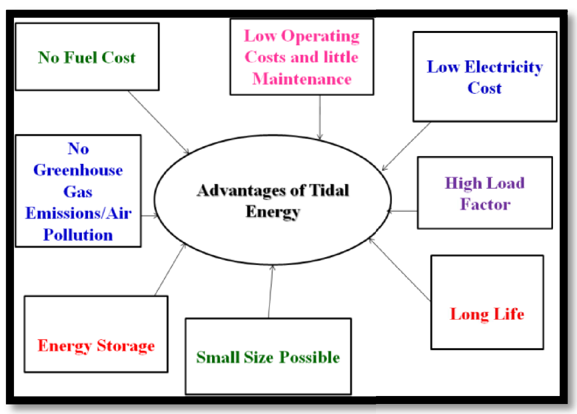

Figure 10: Advantages of Tidal Energy

<u>2. It is green:</u> Tidal energy is also an environmentally friendly energy source because it does not take up a lot of space and does not emit any greenhouse gases. However, there are already some examples of tidal power plants and their effects on the environment.

3. It is predictable: As you know oceanic currents are highly predictable, developing with well-known cycles, which makes it easier to construct tidal energy systems with the correct dimensions, since the kind of power the equipment will be exposed to is already known. This is why both the equipment's installed capacity and physical size have entirely other limitations, though tidal turbines and stream generators that are being used are very similar to wind turbines.

4. It is effective at low speeds: Water is a thousand more dense than air, which makes it possible to produce electricity at low speeds. Energy can be generated even at 1 minute per second, which is equivalent to a little over 3 feet per second.

5. It has a long lifespan: There is no reason to believe that tidal energy plants are not long lived. This means an ultimate reduction of the expenditure spent on selling the electricity, making this energy source a very cost-competitive one. For example, the **La Rance tidal barrage power plant** was developed in 1966 and is still generating large amounts of electricity to till date.

6. It reduces foreign importation of fuel: Through harnessing tidal energy on a large scale, we can help reduce foreign fuels importation and enhance energy security, as people would no longer have to rely much on fuel import to assure the growing energy requirement.

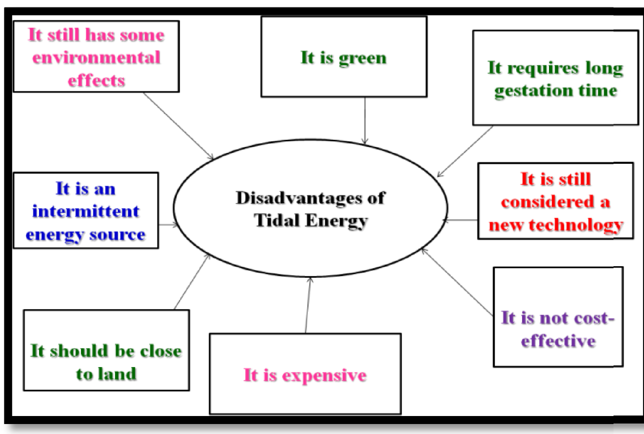

Figure 11: Disadvantages of tidal energy

Disadvantages of Tidal Energy:

1. Tidal energy has some environmental effects**:** As previously mentioned, tidal power plants are suspected to have some environmental effects, but are yet to be determined. As we know these facilities generate electricity with the use of tidal barrages that rely on ocean level manipulation, thus potentially having the same environmental effects as hydroelectric dams. Also, the turbine frames may potentially disrupt the natural movement of aquatic animals, and the construction of the whole plant may also disturb the route of migratory fishes.

2. It is an intermittent energy source: Tidal energy is considered as an irregular source of energy, as it can only provide electricity when the tide generated. On average, the tide surges about 10 hr/ day. This means tidal power can only be considered as unfailing when accompanied with effective energy storage solutions.

3. It should be close to land: Tidal energy infrastructure should be built close to land, which is also the place where technological solutions that come with them are being worked on. In disadvantage, the areas where this energy is produced are far away from the exact locations where it is consumed or needed.

4. It is expensive: **You must** know that the technique of generating tidal energy is relatively a new technology. It is projected that it will be commercially profitable by 2020 in larger scales with better technology. The plants that harness this type of energy are linked to higher upfront costs that are required for construction. Thus, tidal energy displays a lack of cost-effectiveness and efficiency in the world's energy market.

6. It is very new technology: As you know, tidal energy is limited in real life to just a few prototype projects because the technology has just begun to develop and needs plenty of research and huge funds before it reaches the market value.

7. It requires long gestation time: **Sometime** time and expenditure of tidal plant installation overruns, which led to some of them being cancelled. For example Severn Barrage tidal plant in UK. Even, some tidal power plants, the one being planned in Russia, will never be realized because of very long development time.

8. Lack of research: The environmental impacts of tidal barrages and turbines on the marine ecosystem have not been fully observed by the researchers. There has been some research work into how barrages manipulate ocean levels and can have similar negative effects as hydroelectric power.

6.6. Wave (water) Energy

Wave energy or wave power is generated by oceanic surface waves. Wave energy or wave power is also kind of renewable energy and is the largest estimated global resource form of ocean energy. The first patent in wave energy happened in Paris in 1799. There are following types of technologies to generate wave energy:

Absorbers: Absorbers extract energy from the rise and fall of the waves with buoy. Once the energy is extracted it is then converted to electrical energy with a linear or rotatory generator.

Attenuators: Attenuators capture energy by being placed perpendicular to the length of the wave, this cause the attenuator to contentiously flex where segments are connected. This connection is then connected to hydraulic pumps which convert the energy.

Oscillation and Water Column: Oscillation water Columns is a partially submerged enclosed structure, the upper part of the structure, above the water, is filled with air and incoming waves are funneled into bottom part of the structure. Whenever these waves come through the structure it causes the water column to rise and fall with the wave which cause the air in the top structure to pressurize and depressurize, this turn pushes and pulls air through a connected air turbine at the top of the structure.

Overtopping and inverted pendulum Device: Overtopping has wave lift over a barrier which fills a reservoir with the water and is then drained through a hydro turbine. This technology is very similar to a conventional hydropower projects.

Though, wave energy has great potential, its generation is not presently a widely employed commercial technology because of high expenditure. Wave energy system converts the motion of the waves into usable mechanical energy, which in turn, can be used to produce electricity. These systems can be floating or fixed to be the seabed offshore, or may be built at edge on sea. Wave energy is being researched in several industrial nations of the world, particularly Japan, Norway, UK and USA.

6.6.1. Status of Wave Energy in India

India has a long coastline of 7517 km marked along by numerous estuaries and gulfs which makes it attractive for the development of marine energy plants. wave power potential of India is around 40-60GW. However, compared to the developments in other renewable energy technologies, ocean energy technologies like wave and tidal are in their promising stages in India.

Wave power relies on the height of the wave and its period. Primary estimates of wave energy potential along Indian coast is around 5-15 MW/m, so the theoretical estimated potential comes out to be around 40-60 GW. A study by IIT Madras and Credit Rating

Information Services of Indian Ltd have shown that western coast has higher wind power potential compared to eastern coast. IIT Madras have identified potential locations for wave power development along the west coast of India in Maharashtra, Goa, Karnataka and Kerala. Kanyakumari located at the southern tip of Indian peninsula has the highest power owing to the effects of refraction and strong winds. With currently available technologies, amount of power that can be generated using wave energy is much less than the theoretical estimated potential.

Wave energy research in India was initiated in 1983 when the Department of Ocean Development of Government of India provided funds to Indian Institute of Technology, Madras, for carrying out the research. This led to the establishment of a 150 kW Pilot wave energy plant in 1991 at Vizhinjam in Thiruvananthapuram, Kerala. Vizhinjam wave energy plant was the world’s first wave power plant working on Oscillating Water Column (OWC) technology. This technology utilizes the change in levels of water inside caisson as waves approach. As the water level increases in the caisson, the air inside is compressed, which is then used to drive an air turbine. The power generated from this plant, however, varied a lot throughout the year and maximum power was generated only during the monsoon months.

6.6.2. Uses of Wave Energy

There are various uses of wave energy which are given here:

Electricity generation: The most common use of the wave energy is electricity generation. As you know wave energy is produced when electricity generators are placed on the surface of the ocean. Electricity is need of time and its generation from wave energy is most important for the development of the nation.

Water desalination: Desalination is a process in which mineral components of the sea water removed. As you know that drinking water availability reducing day by day therefore, desalination of sea water is need of hour to fulfill the need of drinking water. Wave energy also used to remove the minerals from sea water and

Water pumping: It is also important use of wave energy. Several years before, Australian company explored the potential of installing wave powered water pumps offshore from the coast.

6.6.3. Advantages and disadvantages of Wave energy

There are various advantages and disadvantages of wave energy which are discussed below:

Advantages of Wave Energy

- Wave energy is an abundant, sufficient, adequate and renewable energy resource as the waves are generated by oceanic waves. The best thing about the wave power is that it will never run out.
- Wave energy is pollution free as wave energy generates pollution to the nature compared to other sources of energy. Unlike fossils fuels, wave power creates no harmful by product such as gas, waste and pollution.
- Wave energy reduces dependency on fossil fuels. As you know wave energy consumes no fossil fuels during operational procedure.
- Wave energy is comparatively constant. It is predictable as waves can be accurately forecast several days in advance. We can anticipate waves in ocean.
- Wave energy devices can easily sited with additional wave energy devices added as needed.
- It disperses the wave energy protecting the shoreline from coastal erosion.
- It does not cause any harm to migratory fishes and aquatic animals.

Disadvantages of Wave Energy

- Wave energy conversion devices are depend on location requiring appropriate sites were the waves are consistently enough to produce energy.
- It produces intermittent power, as you know the waves come in intervals and do not generate power during calm periods.
- Wave energy devices which are situated at shores can be a danger to navigation that cannot sense them by RADAR.
- High power distribution costs to send the generated power from offshore devices to the land using long underwater cables.

- They must be able to withstand forces of nature resulting in high capital, construction and maintenance charges.

6.7. Summary

In this unit we have discussed various aspects of Non-conventional sources of energy. So far you have learnt that:

- ***There are various types of Non-conventional sources of energy such as solar energy, wind energy, tidal energy, geothermal energy, wave energy etc.***
- ***Non-conventional energy sources are also called renewable sources of energy.***
- ***Solar power or solar energy is generated by converting solar energy directly into electrical energy. Solar energy or solar power is an essential energy of all non-conventional energy sources. Unfortunately, usable amount of solar energy is very less***
- ***About 5,000 trillion kWh per year energy is incident over Indian land area with most area receiving 4-7 kWh per sq. meter per day.***
- ***Jawaharlal Nehru National Solar Mission (JNNSM) was launched on 11th January, 2009. The target of JNNSM for Grid Connected Solar Projects is about 20,000 MW by 2022.***
- ***Solar power in India is a one of the fastest developing industries. Solar installed capacity of India reached 28.18 GW as of 31 March 2019.***
- ***Solar cooker directs the solar heat into the secondary reflector inside the kitchen, which emphasizes the heat to the bottom of the cooking vessel. It has a covering of a glass plate. These are applicable widely in developing countries. It helps to reduce the deforestation. Solar heaters use solar energy to heat water.***
- ***Advantages of Solar Energy are as: solar energy is clean, renewable, reliable, it reduces the utility costs and It is Multipurpose.***
- ***Disadvantages of Solar energy are as : it depends on weather, expensive, uses a lot of space and creates pollution***

- ***There are various types of solar energy such as : passive solar energy, active solar energy, solar thermal energy, photovoltaic solar power, concentrating solar power.***
- ***Wind power is the use flow of air through wind turbine to provide the mechanical power to turn electric generators. Wind energy supplies variable power, which is very consistent from year to year but has significant variation over shorter period of time. In this mechanism wind turbine works opposite to fan.***
- ***The principle of wind turbine in which energy in the wind turns two or three propellers like blade around rotor. The rotor is connected to main shaft which spins a generator to produce electricity.***
- ***India has the fourth largest installed capacity in wind power after China, United States and Germany. The total installed capacity of wind power in India is about 32 GW.***
- ***The potential of wind energy is concentrated in the states of Andhra Pradesh, Gujarat, Karnataka, Madhya Pradesh, Maharashtra, Rajasthan, Tamil Nadu and Telangana. Tamil Nadu has the highest installed capacity in the India with around 7.5 GW. Climatic factors of Tamil Nadu are very much favourable to wind power development.***
- ***There are several advantages of wind energy which are It is renewable & sustainable, It is environmentally friendly, It can reduce fossil fuel consumption. It is Free, It has a small footprint, It may be used in remote locations, It is cheaper, Low maintenance, Low running costs, High Potential.***
- ***There are some disadvantages of Wind Energy such as wind fluctuation, expensive installation, threat to wildlife, create noise and visual pollution.***
- ***Tidal power is a type of hydropower that converts the energy of tides into electricity. In areas where the sea experiences waves and tides, electricity van be generated by using tidal power. India may take up "ocean thermal***

level conversion" by which it will be able to generate 50,000MW of electricity to meet the power requirements.

- ***The Gujarat government is all set to develop India's first tidal energy plant. The state government has approved Rs 25 crore for setting up the 50 MW plant at the Gulf of Kutch. It will produce energy from the ocean tides.***
- ***There are various advantages of tidal energy which are as : it is renewable, it is green, it is predictable, it is effective at low speeds, it has a long lifespan, it reduces foreign importation of fuel.***
- ***Tidal energy has some environmental effects, It is an intermittent energy source, It should be close to land, It is expensive, It is very new technology, It requires long gestation timeand lack of research are disadvantages of Tidal Energy.***
- ***Wave energy or wave power is generated by oceanic surface waves. Wave energy or wave power is also kind of renewable energy and is the largest estimated global resource form of ocean energy. The first patent in wave energy happened in Paris in 1799.***
- ***India has a long coastline of 7517 km marked along by numerous estuaries and gulfs which makes it attractive for the development of marine energy plants. wave power potential of India is around 40-60GW.***
- ***Wave energy is pollution free as wave energy generates pollution to the nature compared to other sources of energy.***
- ***Wave energy reduces dependency on fossil fuels. As you know wave energy consumes no fossil fuels during operational procedure.***
- ***Visual impact of wave energy conversion devices on the shoreline and offshore floating platforms.***
- ***Wave energy conversion devices are depend on location requiring suitable sites were the waves are consistently enough to produce energy.***
- ***Wave energy devices which are located at shores can be a danger to navigation that cannot detect them by RADAR.***

TERMINAL QUESTIONS

1. **a) Fill in the blank spaces with appropriate words.**

India has the………largest installed capacity in……… ……. after China, United States and Germany. The total installed capacity of wind power in India as on March 2017 is about ……… Wind Energy has spread across the Southern, Western and Northern parts of country. The potential of wind energy is concentrated in the states of Andhra Pradesh, Gujarat, Karnataka, Madhya Pradesh, Maharashtra, Rajasthan, Tamil Nadu and Telangana. ………… ……….has the highest installed capacity in the India with around……….. Climatic factors of Tamil Nadu are very much favourable to wind power development. …………..has the second highest installed capacity of about…….followed by………with third highest installed capacity of about………..in the country. India's largest windmill farm is in ………………………which generates……………of electricity.

2. a). Define the Non-conventional energy sources.

   b) What is Solar energy? Explain

3. (a) Describe the status of solar energy in India.

   (b) Give the Advantages and disadvantages of Solar energy

4. a) Write about uses and types of solar energy

5. (a) Discuss status and uses of wind energy.

(b) Write the advantages and disadvantages of wind energy

(c) What is tidal energy? Describe the status of tidal energy in India

6. (a) **Fill the blank spaces with appropriate words.**

The Gujarat government is all set to develop India's first …….energy plant. The state government has approved Rs ……. ………for setting up the …………..plant at the Gulf of Kutch. It will produce energy from the ocean……….

The state government signed a MoU with Atlantis Resource Corporation last year to develop the plant. "The proposal was approved in this year's budget session," said by Rajkumar Raisinghani, senior executive with ……… ………. ………… ………(GPCL). Atlantis Resource Corporation is a UK-based developer of tidal current turbines. "The equipment has been imported and work will start anytime soon. We are awaiting Coastal

Regulation Zone clearance from Ministry of Environment and Forests, which is expected soon," told by Raisinghani.

According to the GPCL officials, if this 50 MW plant is successfully commissioned, its capacity will be increased to about……….. As per a study conducted by Atlantis Resource Corporation and the state government two years ago, the Gulf of Kutch has a total potential of approximately……….. The biggest operating tidal station in the world, …… ……..in France, generates 240 MW. According to the estimates of the Indian government, the country has a potential of approximately 8,000 MW of tidal energy. This includes about 7,000 MW in the Gulf of Cambay in Gujarat, about 900 MW in the Gulf of Kutch and about 100 MW in the ……….. ……….in the ……………region of West Bengal.

(b) Solar energy is type of (Conventional energy/Non-conventional energy)

(c) Which energy is regarded as pollution free energy (Conventional energy/Non-conventional energy)

(d) Which state of India has highest solar power potential (Rajastha/J&K/Maharastra/Uttarakhand)

(e) What are advantages and disadvantages of tidal energy?

7. (a) Discuss status of wave energy in India.

(b) Describe the advantages and disadvantages of wave energy.

(c) Write a short note on the uses of wave energy.

ANSWERS

1 (a) Fourth, Wind Power, 32 GW, Tamil Nadu, 7.5 GW, Maharastra, 5GW, Gujarat, 4GWKanyakumari, 380MW

2 (a) see section 6.2.

(b) See section 6.3 under heading meaning of solar energy

3 (a) See section 6.3.1.

(b) See section 6.3.3

4 (a) See section 6.3.2 under heading uses of solar energy including fig.6.

5 (a) See the section 6.4.1 and 6.4.2

(b) see the section 6.4.3 under heading advantages and disadvantages of wind energy.

(c) See section 6.5 and 6.5.1.

6 (a) Tidal, 25 crore, 50 MW, tides, Gujarat Power Corporation Limited, 200 MW, 300 MW, La Rance, Gangetic delta, Sunderbans

(b) Non-conventional energy

(c) Non-conventional energy

(d) **Rajasthan**

(e) See the section 6.5.3

7 (a) See the section 6.6.1

(b) See the section 6.6.3

(c) See the section 6.6.2.

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UNIT-7: Non-Conventional Energy Sources II: Geothermal (Earth)

Unit Structure

7.0 Learning Objectives

After studying this unit you will be able to understand:

- Meaning, uses, advantages and disadvantages of geothermal energy
- What is status of geothermal energy in India?
- Meaning, uses, advantages and disadvantages of Nuclear energy
- What is status of Nuclear energy in India?
- Meaning, uses, advantages and disadvantages of Hydrogen energy
- What is status of hydrogen energy in India?

7.1. Introduction

The expansion of possible energy sources has been directly interrelated with the pace of industrial and agriculture development in all the nations of the world. Rapid growth in industrialization, urbanization and in agriculture sectors, the available energy sources began to decline in supply. Conventional energy sources also leading into different types of pollution (air, water, soil, noise etc.). Therefore, Nations all over the global start to look of a policy on energy and look into possibility of having energy systems with least impacts on the environment. We must conserve, protect, preserve the non-renewable conventional sources and replace them by non-polluting renewable sources and it is the need of hour. These non polluting renewable sources are called non-conventional sources of energy. These sources are pollution free, environmentally clean and socially relevant. The common examples of non-convention energy sources are hydrogen energy, solar energy, wave energy, tidal energy, geothermal energy etc. Moreover, no country can afford to depend on only one form of energy. You have learnt about the various forms of non-conventional energy resources solar, wind, tidal and wave energy in Unit-6 of this course. Besides, these non-conventional energy resources there are geothermal, nuclear and hydrogen energy. These energy sources also regarded as non-conventional energy sources. In this unit you will learn about the Non-conventional energy sources viz. geothermal, Nuclear and hydrogen energy.

7.2. Geothermal energy

Geothermal energy is energy generated and stored in the Earth. The GE of the Earth's crust originates from the original formation of the planet. It also originated from radioactive decay of materials. The geothermal gradient, which is the difference in temperature between the core of the planet and its surface, drives a continuous conduction of thermal energy in the form of heat. The word geothermal originates from the two Greek roots in which geo means earth and thermos means hot.

Internal heat of earth is thermal energy produced from radioactive decay and continual heat loss due to the formation of Earth. Temperatures at the core-mantle boundary may reach over 4000 °C. The high temperature and pressure in Earth's interior cause some rock to melt and solid mantle to behave plastically, resulting in portions of the mantle convicting upward since it is lighter than the surrounding rock. Rock and water is heated in the crust, sometimes up to 370 °C (700 °F).

With water from hot spring, geothermal energy has been used for bathing since Paleolithic times and for space heating since ancient Roman times. It is now better known for electricity generation. About 11,700MW of geothermal power was available at global level. An additional 28GW of direct geothermal heating capacity is installed for district heating, space heating, spas, industrial processes, desalination and agricultural applications.

As you know GE is non-conventional and the natural heat of the earth. Interior heat of earth originated from its burning consolidation of soil and gas over 4 billion years ago. It is continually generated by the decay of radioactive materials that occur in all types of rocks. From the surface down through the crust, the normal temperature gradient, the increase of temperature with the increase of depth - in the Earth's crust is 17 °C - 30 °C per kilometer of depth. Below the crust is the mantle, made of highly viscous, partially molten rocks with temperatures between 650 °C -- 1250 °C. At the Earth's core, which consists of a liquid outer core and a solid inner core, temperatures vary from 4000 °C -- 7000 °C. Although geothermal energy development slowed in 2010, with global capacity reaching just over 11 GW, a significant acceleration in the rate of deployment is expected as advanced technologies allow for development in new countries. Heat output from geothermal sources increased by an average rate of almost 9% annually over the past decade, due mainly to rapid growth in the use of ground-source heat pumps**. (Sharma, 2018)**

Geothermal energy has various importance because it is cost-effective, reliable, sustainable, and environmentally friendly. But it has historically been limited to areas near tectonic plate boundaries. Recent technological advances have dramatically expanded the range and size of viable resources, especially for applications such as home heating, opening a potential for widespread exploitation. Geothermal wells release some greenhouse gases trapped deep within the earth, but these emissions are much lower per energy unit than those of fossil fuels.

The Earth's geothermal resources are theoretically more than adequate to supply humanity's energy needs, but only a very small fraction may be profitably exploited. Drilling and exploration for deep resources is very expensive. Forecasts for the future of geothermal power depend on assumptions about technology, energy prices, subsidies, plate boundary movement and interest rates. Pilot programs like EWEB's customer opt in Green Power Program show that customers would be willing to pay a little more for a renewable energy source like geothermal.

7.2.1. Status of geothermal energy in India

India has good potential for geothermal energy; the potential geothermal provinces can produce 10,600 MW of power. But yet geothermal power projects has not been utilized at all, owing to a variety of reasons, the chief being the availability of plentiful coal at cheap costs. However, as environmental problems increasing day to day with coal based projects, India also will need to start depending on clean and eco-friendly energy sources in future. Geothermal energy provides one option as it is non-polluting and eco-friendly.

In India exploration of geothermal energy started in 1970. The Geological Survey of India (GSI) identified 350 locations to produce geothermal energy. The most promising location is in Puga Valley of Ladakh. There are seven geothermal provinces in India namely: The Himalayas, West coast, Cambay, Son-Narmada-Tapi (SONATA), Sohana, Godavari and Mahanadi. The estimated potential for geothermal energy in India appears to be approximately 10,000MW **(Ministry of New and Renewable Energy, 2017).**

Geothermal Provinces in India: The various geothermal provinces in India are classified by the Geological Survey of India and are described below:

The Himalaya Province: It is the region in the coldest part of the country wherein about 100 thermal springs with surface temperatures as high as 90ºC with discharging capacity more than 190 tones/h of thermal water. It is that part of the country where most frequent earthquakes are observed and seismically very sensitive due to the existence of Indo-Eurasian plate boundary. The Geological Survey of India has successfully carried out experiments on space heating using thermal discharge from these thermal springs.

Cambay Province: This province is situated in a failed arm of a rift and forms a part of the Cambay basin overlying the well known Deccan flood basalts. More than 15 thermal springs are located in this province with surface temperatures ranging from 40 to 90ºC. The geothermal well discharge were recorded as more than 125 m3/hr. Higher reservoir temperatures as recorded by at Tuwa and Tulsi Shyam are more than 150ºC.

West coast province: This is located within the famous Deccan flood basalts of Cretaceous age. This province enjoys a thin lithosphere of 18 km thickness thereby rendering this province as one of the most promising sites for exploitation. The thermal discharges are saline are the salinity is about 1%. The reservoir temperatures calculated, after making necessary correction for 1% saline component, are between 102 and 137ºC. The thermal waters are found to have a temperature in the range of 120-200ºC.

SONATA province: This is the area ranging from Cambay in the west to Bakreswar in the east with very high heat flow and geothermal gradient and encloses the well known Tattapani geothermal province with an area of about 80,000m2. The Tattapani province comprises of 23 thermal springs with surface temperatures varying between 60 and 95ºC. Based on thermal gradient and experimental results, it was found to have reservoir temperatures as high as 217ºC at a depth of 3 km from the surface of the earth. Five 6 inches diameter production wells to commission a pilot power plant of 3.17 MW were drilled by the GSI (Sharma, 2018)

Bakreswar province: The Bakreswar-Tantloi thermal province falls in Bengal and Bihar districts and marks the junction between SONATA (Son-Narmada-Tapi) and Singbhum shear zone. High Helium gas is encountered in all the thermal discharges (water and gases) and it is proposed to install a pilot plant to recover Helium from the thermal manifestation of this region.

Godavari province: Godavari valley in Andhra Pradesh is a northwest-southeast trending graben filled with Gondwana sedimentary formations with 13 thermal discharges. The surface temperature of these springs varying from 50 to 60ºC.

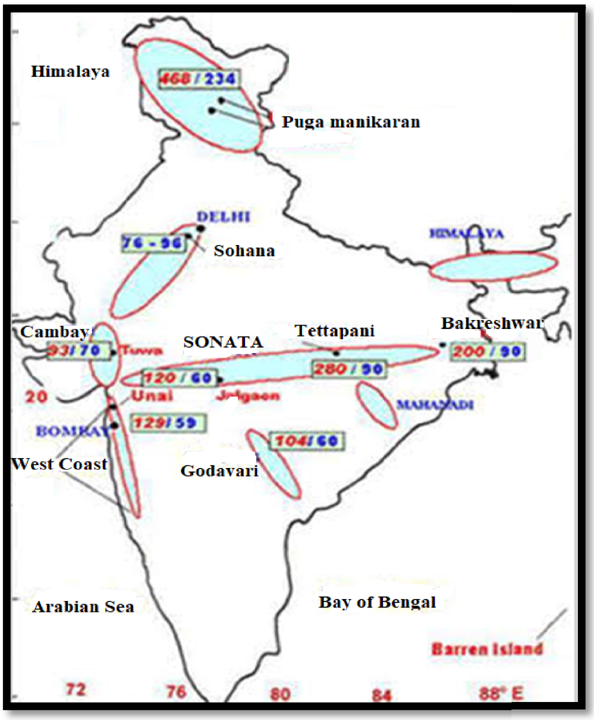

Figure 1: Geothermal potential in India

Geochemical thermometers indicate that the reservoir temperatures varying in the range of 175 and 215ºC. It has been estimated that 38 MW power can be generated from this province.

The Barren Island: The Barren Island forms a part of the Andaman-Nicobar Island in the Bay of Bengal. Volcanic activity recorded in 1991 resulted in the appearance of high temperature steaming ground and thermal discharges with temperatures varying between 100 and 500ºC (**Sharma, 2018).**

7.2.2. Uses of Geothermal Energy

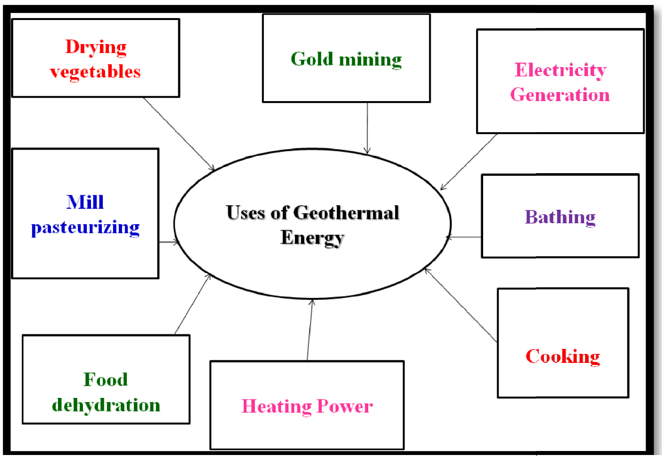

Figure 2: different uses of geothermal energy

There are various uses of geothermal energy which are summarized in Fig-3 and also discussed below:

In, 1997, the world's geothermal electricity generation was 8000MW and another 12000 MW for thermal applications. Italy, New Zealand, USA, Japan, Mexico, Philippines and Indonesia are some of the countries that are using geothermal energy for electricity generation and thermal applications. There are various uses of geothermal energy which are given below:

In direct use hot water from springs or reservoirs located near the surface of the earth. Roman, Chinese, and Native American cultures used hot mineral springs for bathing, cooking, and heating. In present time, many hot springs are used for bathing, and many people believe the hot, mineral-rich waters have natural healing powers. Geothermal energy is also used to heat buildings through district heating systems. Hot water near the earth's surface is piped directly into buildings for heat. A district heating system provides heat for most of the buildings in Reykjavik, Iceland.

GE also used for different industrial purposes. Industrial applications include food dehydration, gold mining, and milk pasteurizing. Drying of vegetable and fruit products, is the one of the most common industrial use of geothermal energy.

The United States leads the world in the amount of electricity generated through geothermal energy. Geothermal electricity generation needs water or steam at high temperatures. Geothermal power plants are generally built where geothermal reservoirs are located, within a mile or two of the earth's surface. In 2017, U.S. geothermal power plants generated about 16 billion kilo watt hours (kWh), or 0.4% of total U.S. utility-scale electricity generation (Sharma, 2018).

Geothermal heat pumps use the constant temperatures near the surface of the earth to heat and cool buildings. Geothermal heat pumps transfer heat from the ground (or water) into buildings during the winter and reverse the process in the summer.

In 2015, 22 countries, including the United States, generated a total of about 76 billion kWh of electricity from geothermal energy. The Philippines was the second-largest geothermal electricity producer after the United States, at about 11 billion kWh of electricity, which equaled approximately 14% of the Philippines' total electricity generation. Kenya was the seventh-largest producer of electricity from geothermal energy at about 4.5 billion kWh of electricity, but it had the largest share of its total electricity generation from geothermal energy at about 47%.(Sharma, 2018)

7.2.3. Advantages and disadvantages of Geothermal Energy

GE is the energy obtained from the earth (geo) from the hot rocks present inside the earth. It is produced due to the fission of radioactive materials in the earth's core and some places inside the earth become very hot. These are called hot spots. They cause water deep inside the earth to form steam. As more steam is formed, it gets compressed at high pressure and comes out in the form of hot springs which produces geothermal power. To harness this geothermal energy, two holes are dug deep into the earth and cold water is pumped through the first one and steam comes out through the second long pipe which helps in generating electricity. The holes dug for harnessing geothermal energy result in lesser emission of greenhouse gases than due to burning of fossil fuels. Thus if used at a larger scale and more efficiently, it gives a hope to reduce global warming. Geo-thermal energy is one of the rare forms of energy which is not directly or indirectly from solar energy. In areas where hot springs are found, hot springs baths are very common and enjoyable form of recreation. However, they need to be in a controlled environment since they cannot be accessed without proper supervision. As you know it is harnessed, the process involved is a long and expensive one and not feasible in some areas. Construction of geothermal energy plants can affect the seismic stability to a large extent. Even though there are lesser emissions, digging deep holes causes seismic disturbances which have led to earthquakes. There are the advantages and disadvantages of GE which are summarized in fig-3 and Fig-4 and also discussed below:

Advantages of Geothermal Energy

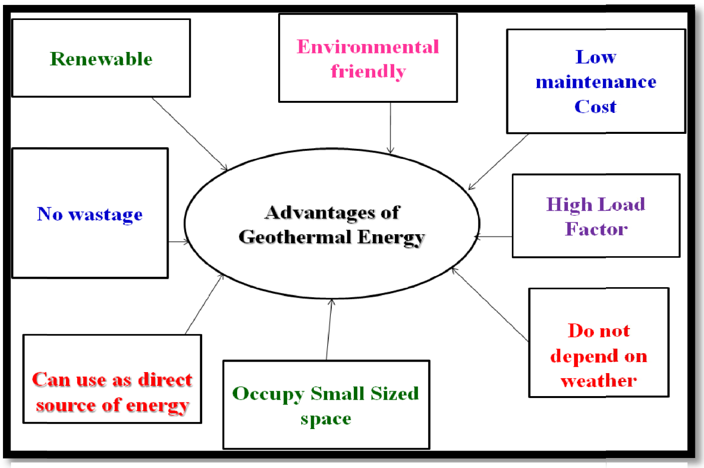

Figure 3: Advantages of geothermal energy

1. As you know geothermal energy is a renewable source of energy. It can be produced again and again. GE produced by the internal heat of earth and it is natural process therefore; it can be used at any time.

2. Geothermal energy has no impact on environment. So far, it is non-polluting and environment friendly.
3. Geothermal energy do not produced and garbage or wastage.
4. Geothermal energy or geothermal power can be used directly. In prehistoric times, people used geothermal energy for heating homes, cooking, etc.
5. Maintenance cost of geothermal power plants is very less; therefore, it is economically very practical.
6. Geothermal power plants don't occupy too much space and consequently help in protecting natural environment of the area.
7. Geothermal energy is not depends on the climatic or weather conditions. Unlike solar energy, it is not dependent on the weather conditions.

Disadvantages of Geothermal Energy:

1) Potential is limited to specific sites. Few areas or sites have the possibility of generation of geothermal energy.

2) The another disadvantages of the GE is the majority of the geothermal energy sites are far from markets or cities, where it needs to be consumed.

3) Total geothermal energy potential of this source is too small.

4) Volcanoes frequently occur in the geothermal energy sites. As you know that volcanoes are dangerous type of disaster and can harm to human being and other infrastructures.

5) In addition to disadvantages the installation cost of geothermal power plant is very expensive.

6) There is no guarantee that the amount of energy produced will validate the capital costs and operations costs.

7) It may release some harmful, toxic gases that can escape through the holes drilled during constructional activities.

7.3. Nuclear Energy

Nuclear energy is also called Nuke energy. Nuclear energy is the use of nuclear reactions that release nuclear energy to generate heat, which most regularly is then used in turbines to produce electricity in a nuclear power plant. As a nuclear technology, nuclear power may be produced from nuclear fission, nuclear fusion and reactions. At present time, the vast majority of electricity from nuclear power is obtained by nuclear fission of uranium and plutonium. Nuclear decay processes are used in niche applications such as radioisotopes thermoelectric generators.

Nuclear power is categorized as a low green house gas energy supply technology, along with renewab;e energy, by the "Intergovernmental Panel on Climate Change". Since commercialization of NE in the 1970s, it has prevented about 1.84 million deaths caused by air pollution and it also prevented emission of about 64 billion tonnes of carbon dioxide equivalent that would have otherwise emitted from the burning of fossil fuels. World Nuclear Association and Environmentalists for Nuclear Energy, argue that nuclear power is a safe, sustainable energy source that reduces carbon emissions. Opponents, such as Greenpeace and NIRS, discussed that nuclear power poses many threats to people and the environment. Therefore, NE is always controversial topic for the whole world (**Ministry of New and Renewable Energy, 2017).**

Nuclear power plants use nuclear fission to produces energy by the reaction of Uranium -235 (Isotope of Uranium). The atoms of uranium rods are split into the process, releasing a large amount of energy. The process continues as a chain reaction with other nuclei. This results into releasing of heat which boils up water and produced steam, which spins a turbine generator and produced electricity. Nuclear energy is off course a principal source of energy, when the fossil fuel reserves are declining at tremendous rate. Very small quantity of radioactive material can produce enormous amount of energy. For example, 1 ton of Uranium would produce as much as energy by three million ton of coal or 12 million barrels of oil.

For atomic energy, we need nuclear reactor. It is used to make steam and channeled through a turbine connected to an electric generator. There are different types of nuclear reactors which are given below:

A. Light water reactor: These reactors are used where we use ordinary water for cooling and moderation. These are of two basic types. (i) Boiling water reactor and (ii) pressurized water reactor.

B. Heavy water reactor: These reactors are used where we use heavy water. The most popular one has been Canadian Deuterium-Uranium (CANDU) reactor. Hence the design is different from that of Light Water Reactor-type.

C. Liquid matter fast breeder reactor: In these reactors we use liquid sodium as the coolant.

   Nuclear power does not create any primary air pollution, but it releases highly radioactive wastes and has environmental and economical costs. Following are the several anxieties which are given below:

Current light water reactors burn the nuclear fuel poorly, leading to energy waste.

The long term radioactive waste storage problems of nuclear power have not been fully solved.

The economics of nuclear power is not simple to evaluate because of high capital costs for building and very low fuel costs.

It may leads in to create the possibility of nuclear disasters such as Three Mile island accident and Chernobyl disaster, has built fear in public.

7.3.1. Status of Nuclear Energy in India

Nuclear energy is the fifth-largest source of electricity in India after coal, gas, hydroelectricity and wind power. India has 22 nuclear reactors in operation in 7 nuclear power plants, having a total installed capacity of 6,780 MW. Nuclear power produced a total of 35 TWh and supplied 3.22% of Indian electricity in 2017. 7 more reactors are under construction with a combined generation capacity of 4,300 MW(**Ministry of New and Renewable Energy, 2017).**

In October 2010, India drew up a plan to reach a nuclear power capacity of 63 GW in 2032, but after the 2011 Fukushima nuclear disaster in Japan people around proposed Indian nuclear power plant sites have launched protests, raising questions about atomic energy as a clean and safe alternative to fossil fuels. There have been strong protests against the French-backed 9,900 MW Jaitapur Nuclear Power Project in Maharashtra and the Russian-backed 2,000 MW Kudankulam Nuclear Power Plant in Tamil Nadu. The state government of West Bengal, has also refused permission to a proposed 6,000 MW facility near the town of Haripur that intended to host six Russian reactors. A Public Interest Litigation (PIL) has also been filed against the government's civil nuclear programme at the Supreme Court. (**Ministry of New and Renewable Energy, 2017).**

Nuclear power in India has suffered from generally low capacity factors. As of 2017, the lifetime weighted energy availability factor of the Indian fleet is 63.5%. However, capacity factors have been improving in recent years. The availability factor of Indian reactors was 69.4% in the years 2015-2017. One of the main reasons for the low capacity factors is lack of nuclear fuel. India has been making advances in the field of thorium-based fuels, working to design and develop a prototype for an atomic reactor using thorium and low-enriched uranium, a key part of India's three stage nuclear power programme. India has also recently re-initiated its involvement in the LENR research activities, in addition to supporting work done in the fusion power area through the ITER initiative.

Table-1: Showing nuclear power plants in India (**Source: NPCIL/CSO, 2013)**

Power station	**Operator**	**In operation**	**Under Construction**	**State**	**Total capacity (MW)**
Kaiga	NPCIL	4	1	Karnataka	880
Kakrapar	NPCIL	2	2	Gujarat	440
Kudankulam	NPCIL	-	2	Tamil Nadu	2,000
Kalpakkam	NPCIL	2	1	Tamil Nadu	440
Narora	NPCIL	2	-	Uttar Pradesh	440
Rawatbhata,	NPCIL	6	2	Rajasthan	1,180

Rajasthan					
Tarapur	NPCIL	4	-	Maharashtra	1,400
TOTAL		**20**	**8**		**4780**

NPCIL= Nuclear Power Corperation of India Ltd.

India has been using imported enriched uranium for light-water reactors that are presently under IAEA safeguards, but it has developed other aspects of the nuclear fuel cycle to support its reactors. Establishment of select technologies has been strongly affected by limited imports. Use of heavy water reactors has been particularly attractive for the nation because it allows Uranium to be burnt with little to no enrichment capabilities. India has also done a great amount of work in the development of a thorium centred fuel cycle. While uranium deposits in the nation are limited while India much greater reserves of thorium and it could provide hundreds of times the energy with the same mass of fuel. The fact that thorium can theoretically be utilised in heavy water reactors. A prototype reactor that would burn Uranium-Plutonium fuel while irradiating a thorium blanket is under construction at Kalpakkam, Tamil Nadu by BHAVINI (**NPCIL/CSO, 2013).**

Uranium used for the weapons programme has been separated from the power programme, using uranium from indigenous reserves. This domestic reserve of 80,000 to 112,000 tons of uranium (approx 1% of global uranium reserves) is large enough to supply all of India's commercial and military reactors as well as supply all the needs of India's nuclear weapons arsenal. At present, India's nuclear power reactors consume, at most, 478 tonnes of uranium per year. Even if India were quadruple its nuclear power output (and reactor base) to 20 GW by 2020, nuclear power generation would only consume 2000 tonnes of uranium per annum. Based on India's known commercially viable reserves of 80,000 to 112,000 tons of uranium, this represents a 40–50 years uranium supply for India's nuclear power reactors (note with reprocessing and breeder reactor technology, this supply could be stretched out many times over). Furthermore, the uranium requirements of India's Nuclear Arsenal are only a fifteenth (1/15) of that required for power generation (approx. 32 tonnes), meaning that India's domestic fissile material supply is more than enough to meet all needs for it strategic nuclear arsenal. Therefore, India has sufficient uranium resources to meet its strategic and power requirements for the foreseeable future (**NPCIL/CSO, 2013**)

Table-2: Nuclear power plants and reactors under construction in India **Source: NPCIL/CSO, 2013)**

Power station	Operator	State	Total capacity (MW)	Expected Operation	Commercial
Madras (Kalpakkam)	Bhavini	Tamil Nadu	500	2020	
Kakrapar Unit 3 and 4	NPCIL	Gujarat	1,400	2022	
Gorakhpur	NPCIL	Haryana	1,400	2022	
Rajasthan Unit 7 and 8	NPCIL	Rajasthan	1,400	2022	
Kudankulam Unit 3 and 4	NPCIL	Tamil Nadu	2,000	2025-2026	
Total			**6,700**		

Table-3: Planned nuclear power plants in India **(Source: NPCIL/CSO, 2013)**

Power station	Operator	State	Total capacity (MW)
Jaitapur	NPCIL	Maharashtra	9,900
Kovvada	NPCIL	Andhra Pradesh	6,600
Kavali	NPCIL	Andhra Pradesh	6000
Gorakhpur	NPCIL	Haryana	1,400
Bhimpur	NPCIL	Madhya Pradesh	2,800
Mahi Banswara	NPCIL	Rajasthan	2,800
Kaiga	NPCIL	Karnataka	1,400
Chutka	NPCIL	Madhya Pradesh	1,400
Kudankulam Unit 5 and 6	NPCIL	Tamil Nadu	2,000

Madras	BHAVINI	Tamil Nadu	1,200
Tarapur			300
Total			**41,800**

India has been a leader in making peaceful use of nuclear power in **medical sciences**, **agricultural** and **space technology**. India has many resources of certain minerals such as **thorium**. **Uranium** mines are also located in **Singhblum**, **Bihar** and some regions of **Rajasthan**. Most abundant source is **monazite** sands on shores of **Kerala**. Thorium is derived from these sands. In India, **Nuclear power Corporation of India Ltd. (NPCIL)** is engaged with establishment of nuclear power plants. India is **seventh** nation in world to have mastered the nuclear fuel cycle. The gross generation of electricity as nuclear power in India in 1970-1971 was **2418GWh**, which increased with time. During 2010-11 it was **26266GWh** increasing to **33286GWh** in 2012. As per Central Statistics Office (CSO) report in India there are **twenty** nuclear reactors in operations and eight under construction in different states of India. Nuclear power supplies about 2-4% of India's electricity and in 2050, it is expected to rise **25%.** (**Energy statistics 2015)**

7.3.2. Uses of Nuclear Energy

There are a number of uses of nuclear energy and these uses range from agriculture to medical, and space exploration to water desalination. Beside electricity, atomic power is used as fuel for marine vessels, heat generation for chemical and food processing plants and for spacecrafts.

Agriculture and Food: In many parts of the world, farmers use radiation to prevent harmful insects from reproducing. When insects cannot have offspring, there are fewer of them. Reducing the numbers of pests and bugs protects crops, providing the world with more food. Irradiation also kills bacteria and other harmful organisms in food. This type of sterilization occurs without making food radioactive or significantly affecting the nutritional value. In fact, irradiation is the only way to kill bacteria in raw and frozen foods effectively.

Medical: Nuclear energy technologies provide images inside the human body and can help to treat disease. For example, nuclear research has allowed doctors to predict precisely the amount of radiation required to kill cancer tumors without damaging healthy cells. Hospitals sterilize medical equipment with gamma rays safely and inexpensively. Items sterilized by radiation include syringes, surgical gloves and heart valves.

Space Exploration: Nuclear technology makes deep space exploration possible. The generators in unmanned spacecraft use the heat from plutonium to generate electricity and can operate unattended for years. This reliable, long-term source of electricity powers these spacecraft, even as they venture deep into space.

Water Desalination: The World Nuclear Association notes that 1/5 of the population of world does not have access to safe drinking water and that number is expected to grow. Nuclear technology can play an important role in overcoming this challenge. Water desalination is the process of removing salt from saltwater to make the water drinkable. However, this process requires a lot of energy. Nuclear energy facilities can provide the large amount of energy that desalination plants need to provide fresh drinking water.

7.3.3. Advantages and Disadvantages of Nuclear Energy

Nuclear energy can release 1 million times more energy per atom than fossil fuels. It can also be integrated into electricity grids, which currently utilize fossil fuel generation, with few changes to existing facilities. Nuclear has large power-generating capacity and low operating costs, making it ideal for base load generation. However, upfront capital costs are intensive and present financial risk to investors given the extended time frames power plants must operate to recuperate their costs. NE does not emit greenhouse gas emissions. For this reason, it is often seen as a substitute for fossil fuel energy generation and remedial measures for mitigating global warming. However, nuclear fission has a wide variety of environmental and health issues associated with electricity generation. The largest concern is the generation of radioactive wastes such as uranium mill tailings, spent reactor fuel, and other radioactive wastes. Some of these materials can remain radioactive and hazardous to nature, plants and animals. Numerous large nuclear meltdowns in history released radioactive waste that had lasting negative impacts on the environment and surrounding communities.

The radiation due to nuclear energy made nuclear fission technologies controversial. There are various advantages and disadvantages of nuclear energy which are discussed below:

Advantages of Nuclear energy

- Nuclear energy tackles 3 of the greatest problems humanity has encountered in its struggle to get energy.
- Nuclear power plants do not require a lot of space.
- Nuclear energy is the most concentrated form of energy.
- It is boon to medical and agricultural sciences.

Disadvantages of Nuclear energy

- One of the main disadvantages of nuclear energy is that nuclear explosions produce radiation, this radiation destroys cells of the body which can make humans sick or even cause them death. Disabilities can become visible or exposed people who have exposed to nuclear radiation.
- A possible type of reactor disaster is known as a meltdown. In a meltdown, the fission reaction of an atom goes out of control, which leads to a nuclear explosion releasing great amounts of radiation.
- In 1979, at the Three Mile Island near Harrisburg, Pennsylvania, the cooling system of a nuclear reactor failed. Radiation escaped, forcing tens of thousands of people to run away. Fortunately the problem was solved minutes before a total meltdown would have occurred, and there were no deaths.
- In 1986, a much worse disaster hit Russia's Chernobyl nuclear power plant. In this disaster, a large amount of radiation escaped from the reactor. Hundreds of thousands of people were exposed to the radiation. Dozens of people died within a few days and in the upcoming times, thousands more may die due to cancers induced by the radiation.

- Reactors produce nuclear waste products which produce dangerous radiation, because they could kill people who touch them, they cannot be thrown away like ordinary garbage.
- Another disadvantage is that nuclear reactors only last for about forty to fifty years and not for long lasting.

7.4. Hydrogen Energy

Hydrogen is a clean fuel. At standard temperature and pressure, hydrogen is a nontoxic, nonmetallic, odorless, tasteless, colorless, and highly combustible diatomic gas with the molecular formula H_2.

As you know hydrogen is the most abundant element in the universe. The sun and other stars are composed largely of hydrogen. Astronomers already predicted that 90% of the atoms in the universe are hydrogen atoms. Hydrogen is a component of more compounds than any other element. Water is the most abundant compound of hydrogen found on earth. Molecular hydrogen is not available on Earth in convenient natural reservoirs. Most hydrogen on Earth is bonded to oxygen in water and to carbon in live or fossilized biomass. It can be produced by splitting water into hydrogen and oxygen.

Its preparation could be done by breaking the chemical bonds from compounds. A few common methods include electrolysis, from steam and hydro carbon or carbon, reaction of metals with acids, ionic metal hydrides with water, etc. At present time, global hydrogen production is 48% from natural gas, 30% from oil, and 18% from coal, Water electrolysis accounts for only 4% hydrogen production worldwide.

The storage of hydrogen is vital because it has wide range of applications. They range from stationary power, portable power to transportation, etc. HE has the highest energy per mass of any fuel. However, its low ambient temperature density results in a low energy per unit volume, therefore requiring the development of advanced storage methods that have potential for higher energy density. Hydrogen can be stored as either a gas or a liquid. Storage of hydrogen as a gas typically requires high-pressure tanks 5,000–10,000 psi tank pressure. Storage of hydrogen as a liquid requires cryogenic temperatures because the boiling point of hydrogen at one atmosphere pressure is −252.8°C. Hydrogen can also be stored on the surfaces of solids (by adsorption) or within solids (by absorption). **Sharma, 2018)**

Hydrogen is considered an alternative fuel. It is due to its ability to power fuel cells in zero-emission electric vehicles, its potential for domestic production, and the fuel cell's potential for high efficiency. In fact, a fuel cell coupled with an electric motor is two to three times more efficient than an internal combustion engine running on gasoline.

7.4.1. Status of Hydrogen Energy in India

In India, the National Hydrogen Energy Road Map (NHERM) was set and adopted by the National Hydrogen Energy Board in 2006 for execution. The main purpose of National Hydrogen Energy Road Map (NHERM) was to identify the pathways, which will lead to steady introduction of hydrogen energy, step up commercialization efforts and make possible the creation of hydrogen energy infrastructure in India. National Hydrogen Energy Road Map (NHERM) covered all aspects of hydrogen energy development in India including its production, storage, transport, delivery, application, codes & standards, public awareness and capacity building. National Hydrogen Energy Road Map (NHERM) formed the basis for implementation of Hydrogen Energy Progamme in the country from 2006 - 07 onwards. National Hydrogen Energy Road Map (NHERM) suggested modifying and upgrading it later based on field experience in the country and new developments worldwide. Therefore, a Steering Committee on Hydrogen Energy and Fuel Cells was prepared by the Ministry of New and Renewable Energy (MNRE).

The Ministry of New and Renewable Energy also appreciates research, development and demonstration projects on various aspects of hydrogen energy including its production, storage and use as a fuel for generation of mechanical/thermal/electrical energy. As a result, Hydrogen fueled small power generating sets, two wheeler (motor cycles), three wheeler, catalytic combustion systems for residential and industrial sectors and fuel cell buses have also been developed and demonstrated.

7.4.2. Status of Hydrogen-based Technologies in India

Production: The Banaras Hindu University (BHU); Murugappa Chettiar Research Centre (MCRC), Chennai; and IIT, Kharagpur are among the leading research groups working on biological, biomass, and other renewable energy routes to produce hydrogen. With R&D support from the MNES, the MCRC has demonstrated hydrogen production in batch-scale from distillery waste. The pilot plant is able to produce up to 18 000 liters of hydrogen per hour.

The BHU, IIT Chennai, and the National Physical Laboratory are working on the hydrogen storage methods. The BHU has developed various types of metal hydrides with storage capacities of up to 2.4 weight percentage. It has also confirmed the use of 1.6% weight storage in metal hydride on a pilot scale. Hydrogen-operated motorcycles and three-wheelers have been developed and demonstrated. The BHU has modified a commercially available motorcycle of 100 cc, four strokes and a three-wheeler of 175 cc, four strokes to operate on hydrogen as a fuel.

Table-4: Status of Major Technologies in the field of Hydrogen Energy

Technology	International Status	National Status
Coal Gasification(IGCC)	Commercially available	Efforts underway to set up pilot plant
Biological route for Hydrogen Production	In Pre-Commercial stage	Demonstration Plant set up
Metal Hydrides for Hydrogen storage	Metal Hydrides for Hydrogen storage Hydrides with 1.5 - 2.0wt% storage capacity for ambient conditions developed	Hydrides with 2.42wt% storage capacity for ambient conditions developed
Carbon Nano-structures for Hydrogen Storage	In R&D Stage	In R&D Stage, Further R&D efforts underway
IC Engine for Hydrogen	Not commercially available	Dedicated engine to be developed
PEM Fuel Cells for Stationary applications and automobiles	Commercially available	Prototype Demonstrated, PEMFC of international specifications and suitable for automobiles to be developed

Solid Oxide Fuel Cells	In R & D Demonstration Stage	In early stages of R&DStatus

7.4.3. Uses of Hydrogen Energy

Hydrogen is a colorless, odorless, tasteless, flammable gas. It is found in water, organic compounds, biomass, and hydrocarbons such as petrol, natural gas, methanol, and propane. Hydrogen is high in energy content as it contains 120.7 kj/gm. This is the highest energy content per unit mass among known fuels. However, its energy content per unit volume is rather low. Thus, challenges are greater in the storage of hydrogen for civilian applications, as compared to storage of liquid fossil fuels. When burnt, hydrogen produces water as a by-product and is therefore not only an efficient energy carrier but a clean, environmentally benign fuel as well. Hydrogen can be used for power generation and also for transport applications. It is possible to use hydrogen in internal combustion (IC) engines, directly or mixed with diesel and compressed natural gas (CNG) or hydrogen can also be used directly as a fuel in fuel cells to produce electricity. Hydrogen energy is often mentioned as a potential solution for several challenges that the global energy system is facing. The advantages are the fact that hydrogen use results in nearly zero emissions at end-use, and that hydrogen opens up the possibility of decentralized production on the basis of a variety of fuels. But it is found that hydrogen will not play a major role in India without considerable research, technology innovations and cost reductions, mainly in fuel cell technology. There are various uses of hydrogen energy which are given below:

Hydrogen energy use to produce electricity. Fuel cells are the technology for use as a source of heat and electricity for buildings. In future, hydrogen energy could also join electricity. Hydrogen can also be transported to areas where electricity required. Hydrogen is also used in industrial processes such as refining, treating metals, food processing. Hydrogen fuel can provide motive power for liquid-propellant rockets, cars, boats and airplanes which can power an electric motor.

Advantages and disadvantages of Hydrogen Energy

There are various advantages and disadvantages of hydrogen energy which are summarized in Fig-5 and Fig-6 and also discussed below:

Advantages of Hydrogen Energy:

<u>It is readily available</u>. It is a basic earth element and is very abundant. However, it time consuming to separate hydrogen gas from its companion substances. While that may be the case, the results produce a powerful clean energy source.

<u>It doesn't produce harmful emissions</u>. When it is burned, it doesn't emit harmful substances. Basically, it reacts with oxygen without burning and the energy it releases can be used to generate electricity used to drive an electric motor. Also, it doesn't generate carbon dioxide when burnt, not unlike other power sources.

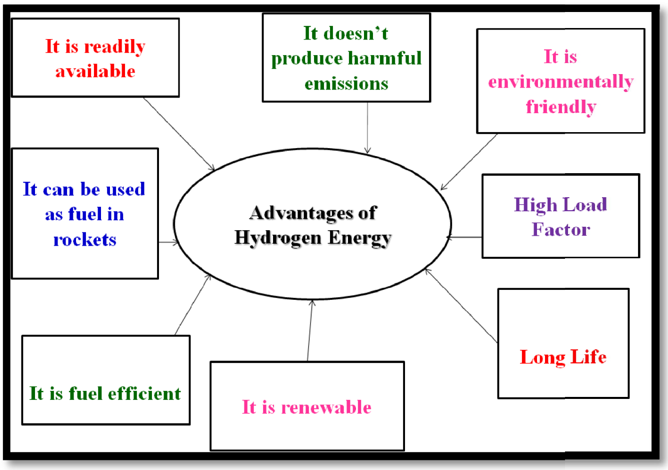

Figure 4- Advantages of Hydrogen Energy

<u>It is environmentally friendly</u>. It is a non-toxic substance which is rare for a fuel source. Others such as nuclear energy, coal and gasoline are either toxic or found in places that have hazardous environments. Because hydrogen is friendly towards the environment, it can be used in ways that other fuels can't even possibly match.

<u>It can be used as fuel in rockets</u>. It is both powerful and efficient. It is enough to provide power for powerful machines such as spaceships. Also, given that it is environmentally friendly, it is a much safer choice compared to other fuel sources. A fun fact: hydrogen is three times as powerful as gasoline and other fossil fuels. This means that it can accomplish more with less.

<u>It is fuel efficient.</u> Compared to diesel or gas, it is much more fuel efficient as it can produce more energy per pound of fuel. This means that if a car is fueled by hydrogen, it can go farther than a vehicle loaded with the same amount of fuel but using a more traditional source of energy. Hydrogen-powered fuel cells have two or three times the efficiency of traditional combustion technologies. For example, a conventional combustion-based power plant usually generates electricity between 33 to 35 percent efficiency. Hydrogen fuel cells are capable of generating electricity of up to 65 percent efficiency.

It is renewable. It can be produced again and again, unlike other non-renewable sources of energy. This means that with hydrogen, you get a fuel source that is limited. Basically, hydrogen energy can be produced on demand.

Disadvantages of Hydrogen Energy:

It is expensive. While widely available, it is expensive. A good reason for this is that it takes a lot of time to separate the element from others. If the process were really simple, then a lot would have been doing it with relative ease, but it's not. Although, hydrogen cells are now being used to power hybrid cars, it's still not a feasible source of fuel for everyone. Until technology is developed that can make the whole process simpler, then hydrogen energy will continue to be an expensive option.

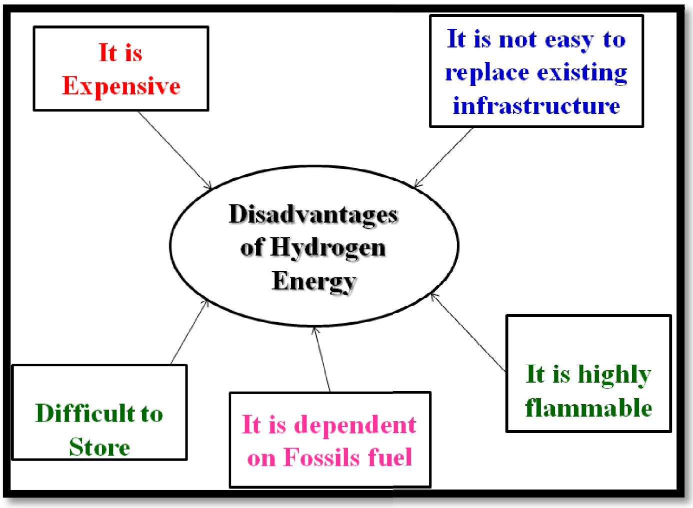

Figure 5: Disadvantages of Hydrogen Energy

It is difficult to store: Hydrogen is very hard to move around. When speaking about oil, that element can be sent though pipelines. When discussing coal, that can be easily carried off on the back of trucks. When talking about hydrogen, just moving even small amounts is a very expensive matter. For that reason alone, the transport and storage of such a substance is deemed impractical.

It is not easy to replace existing infrastructure: Gasoline is still being widely used to this day. And as of the moment, there just isn't any infrastructure that can support hydrogen as fuel. This is why it becomes highly expensive to just think about replacing gasoline. Also, cars need to be refitted in order to accommodate hydrogen as fuel.

It is highly flammable: Since it is a very powerful source of fuel, hydrogen can be very flammable. In fact, it is on the news frequently for its many number of risks. Hydrogen gas burns in air at very wide concentrations – between 4 and 75 percent.

It is dependent on fossil fuels: Although hydrogen energy is renewable and has minimal environmental impact, other non-renewable sources such as coal, oil and natural gas are needed to separate it from oxygen. While the point of switching to hydrogen is to get rid of using fossil fuels, they are still needed to produce hydrogen fuel.

7.5. Summary

In this unit we have discussed various non-conventional energy sources such as Geothermal, Nuclear and Hydrogen energy. So far you have learnt that:

- ***The geothermal energy of the Earth's crust originates from the original formation of the planet. It also originated from radioactive decay of materials. The word geothermal originated from the two Greek roots in which geo means earth and thermos means hot.***
- ***India has good potential for geothermal energy; the potential geothermal provinces can produce 10,600 MW of power. India also will need to start depending on clean and eco-friendly energy sources in future. Geothermal energy provides one option as it is non-polluting and eco-friendly.***
- ***In India exploration of geothermal energy started in 1970. The Geological Survey of India (GSI) identified 350 locations to produce geothermal energy. The most promising location is in Puga Valley of Ladakh. There are seven geothermal provinces in India namely: The Himalayas, West coast, Cambay, Son-Narmada-Tapi (SONATA), Sohana, Godavari and Mahanadi. The estimated potential for geothermal energy in India appears to be approximately 10,000MW.***
- ***Main advantages of GE are as it is renewable; it has no impact on environment. Geothermal energy do not produced and garbage or wastage. Geothermal energy or geothermal power can be used directly. Geothermal***

power plants don't occupy too much space and consequently help in protecting natural environment of the area.

- ***There are few disadvantages of GE such as it is limited to specific sites, geothermal energy sites are far from markets or cities, geothermal energy potential of this source is too small, and volcanoes frequently occur in the geothermal energy sites. Installation cost of geothermal power plant is very expensive.***
- ***Nuclear energy is also called Nuke energy. Nuclear energy is the use of nuclear reactions that release nuclear energy to generate heat, which most regularly is then used in turbines to produce electricity in a nuclear power plant. As a nuclear technology, nuclear power may be produced from nuclear fission, nuclear fusion and reactions.***
- ***At present time, the vast majority of electricity from nuclear power is obtained by nuclear fission of uranium and plutonium. Nuclear decay processes are used in niche applications such as radioisotopes thermoelectric generators.***
- ***India has been a leader in making peaceful use of nuclear power in medical sciences, agricultural and space technology. India has many resources of certain minerals such as thorium. Uranium mines are also located in Singhblum, Bihar and some regions of Rajasthan. Most abundant source is monazite sands on shores of Kerala. Thorium is derived from these sands. In India, Nuclear power Corporation of India Ltd. (NPCIL) is engaged with establishment of nuclear power plants.***
- ***India is seventh nation in world to have mastered the nuclear fuel cycle. The gross generation of electricity as nuclear power in India in 1970-1971 was 2418GWh, which increased with time. During 2010-11 it was 26266GWh increasing to 33286GWh in 2012.***
- ***As per Central Statistics Office report in India there are twenty nuclear reactors in operations and eight under construction in different states of***

India. Nuclear power supplies about 2-4% of India's electricity and in 2050, it is expected to rise 25%.

- ***There are a number of uses of nuclear energy and these uses range from agriculture to medical, and space exploration to water desalination. Beside electricity, atomic power is used as fuel for marine vessels, heat generation for chemical and food processing plants and for spacecrafts.***
- ***The main advantages of Nuclear energy are as nuclear energy is the most concentrated form of energy and it is boon to medical and agricultural sciences.***
- ***The common disadvantages of nuclear energy are as : nuclear energy is that nuclear explosions produce radiation, this radiation destroys cells of the body which can make humans sick or even cause death. Disabilities can become visible or exposed people who have exposed to nuclear radiation.***
- ***Hydrogen is a clean fuel, at standard temperature and pressure, hydrogen is a nontoxic, nonmetallic, odorless, tasteless, colorless, and highly combustible diatomic gas with the molecular formula H_2.***
- ***Hydrogen-based Technologies in India are The Banaras Hindu University (BHU); Murugappa Chettiar Research Centre (MCRC), Chennai; and IIT, Kharagpur are among the leading research groups working on biological, biomass, and other renewable energy routes to produce hydrogen. With R&D support from the MNES, the MCRC has demonstrated hydrogen production in batch-scale from distillery waste. The pilot plant is able to produce up to 18 000 liters of hydrogen per hour.***
- ***The BHU, IIT Chennai, and the National Physical Laboratory are working on the hydrogen storage methods. The BHU has developed various types of metal hydrides with storage capacities of up to 2.4 weight %. It has also demonstrated the use of 1.6% weight storage in metal hydride on a pilot scale.***

- ***Hydrogen-operated motorcycles and three-wheelers have been developed and demonstrated. The BHU has modified a commercially available motorcycle and a three-wheeler to operate on hydrogen as a fuel.***
- ***There are various uses of hydrogen energy which are as production of electricity, heat and water for various end uses, industrial applications, vehicular transportation, residential applications and commercial applications, including in telecom towers for providing back-up power***
- ***The advantages of hydrogen energy are as it is readily available, it doesn't produce harmful emissions, it is environmentally friendly, it can be used as fuel in rockets, it is fuel efficient and it is renewable.***

The main disadvantages of hydrogen energy are as it is expensive, it is difficult to store, it is not easy to replace existing infrastructure, it is highly flammable, and it is dependent on fossil fuels.

TERMINAL QUESTIONS

(a) Fill in the blank spaces with appropriate words.

India has good potential for …….energy; the potential geothermal provinces can produce ……………of power. But yet geothermal power projects has not been utilized at all, owing to a variety of reasons, the chief being the availability of plentiful coal at cheap costs. However, as environmental problems increasing day to day with coal based projects, India also will need to start depending on clean and eco-friendly energy sources in future. ………… ………….provides one option as it is non-polluting and eco-friendly.

In India exploration of geothermal energy started in………. The ………… …………… …. ………….(GSI) identified ………. ……….to produce geothermal energy. The most promising location is in……… ……… ……… ………. There are ……..geothermal provinces in India namely: The………., West coast, ……………, Son-Narmada-Tapi (…….), Sohana, ……………and Mahanadi. The estimated potential for geothermal energy in India appears to be approximately ……………….

(a) Write a short note on geothermal energy.

(b) What do you understand by geothermal energy? Give the status of geothermal energy in India.

3. (a) Describe uses of geothermal energy.
   (b) Describe the advantages and disadvantages of geothermal energy
4. (a) What are the uses of Nuclear energy
5. (a) Discuss the status of nuclear power in India

6. (a) Fill the blank spaces with appropriate words.

India has been a leader in making peaceful use of nuclear power in………..,………. and…………… ……….. India has many resources of certain minerals such as……….. …………mines are also located in …………,…………and some regions of……….. Most abundant source is …………sands on shores of……….. Thorium is derived from these sands. In India, ……….. ………… ………. ……… ………(NPCIL) is engaged with establishment of nuclear power plants. India is …………nation in world to have mastered the nuclear fuel cycle. The gross generation of electricity as nuclear power in India in 1970-1971 was………, which increased with time. During 2010-11 it was …………. increasing to ………….. in 2012. As per Central Statistics Office (CSO) report in India there are …………nuclear reactors in operations and eight under construction in different states of India. Nuclear power supplies about 2-4% of India's electricity and in 2050, it is expected to rise ………..

(b) Which energy is also known as Nuke energy? (Hydrogen/Biomass/Geothermal/Nuclear)

(c) Which forms is regarded as the most concentrated energy (Solar/Wind/Nuclear/Geothermal)

(d) How many operational of nuclear power plant in India? (10/20/30/40)

(e) What are the advantages and disadvantages of Nuclear Energy?

7 (a) Describe the hydrogen energy, uses and its status of in India

(b) What are the advantages and disadvantages of Hydrogen Energy?

ANSWERS

1 (a) Geothermal, 10,600 MW, Geothermal energy, 1970, Geological Survey of India, 350 locations, Puga Valley of Ladakh, seven, Himalayas, Cambay, SONATA, Godavari, 10,000MW.

2 (a) see section 7.2.

(b) See section 7.2 and 7.2.1

3 (a) See section 7.2.2 with Fig-2

(b) See section 7.2.3. and Figure-3 and Figure-4

4 (a) See section 7.3.2

5 (a) See the section 7.3.1

6 (a) medical sciences, agricultural, space technology, thorium, Uranium Singhblum, Bihar, Rajasthan, monazite, Kerala, Nuclear power Corporation of India Ltd., seventh, 2418GWh, 26266GWh, 33286GWh, twenty, 25%.

(b) Nuclear

(c) Nuclear

(d) 20

(e) See the section 2.4 under heading bioremediation

7 (a) See the section 7.4 and 7.4.1

(b) See the section 7.4.3 and Fig-5 and Fig-6

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UNIT-8: The policies: Global and National (India: National Energy Policy, National Biodiesel Policy, National Energy Mission and Climate Change)

Unit Structure

8.0 Learning Objectives

After studying this unit you will be able to understand:

- What is Energy policy?
- National energy mission and climate change
- About National biodiesel policy
- Human resources in the field of energy conservation, climate change assessment, adaptation and mitigation.

8.1. Introduction

Energy is acknowledged as a key input towards raising the living standard of citizens of any nation. Energy policies of India have therefore, directly aimed to raise per capita energy consumption. With nearly 304 million Indians without access to electricity, and about 500 million people, still dependent on solid bio-mass for cooking. India has still to go a long way on securing its energy security objectives. India strives to achieve a double digit growth rate in its national income, making clean energy available to all of its citizens, ought to be included as a key component of the poverty alleviation programs.

In this unit you will learn about the different energy policies such as national energy policy, national biodiesel policy, national energy mission and climate change.

8.2. The policies

Energy required in every sectors of the development. As you know that demand of energy is increasing day by day at local and global level, therefore its conservation is very important. Almost every nation conserves the energy and has formed different policies for the conservation of energy. Every policy which is emphasized on the conservation of energy is called energy policy. It is the process in which energy production, consumption, distribution have been decided by the Governments. At the global level our country is a major energy consumer and made various policies on energy which are discussed below:

8.2.1. National Energy Policy

The **National Energy Policy (NEP)** is an extensive scale policy which covering the whole national energy system in India. The policy focuses on two time horizons: near-term to 2022, and medium-term to 2040. The NEP emphasizes on key areas: The policy aims to provide clean cooking technologies to all within a "reasonable time" to achieve public acceptability by ensuring economic and environmental sustainability.

The National Energy Policy (NEP) aims to chart the way forward to meet the Government's recent bold announcements in the energy domain. All the Census villages are planned to be electrified by 2018, and universal electrification is to be achieved, with 24x7 electricity by 2022. The share of manufacturing in our GDP is to go up to 25% from the present level of 16%, while the Ministry of Petroleum is targeting reduction of oil imports by 10% from 2014-15 levels, both by 2022. India's NDCs target at reduction of emissions intensity by 33%-35% by 2030 over 2005, achieving a 175 GW renewable energy capacity by 2022, and share of non-fossil fuel based capacity in the electricity mix is aimed at above 40% by 2030. In view of the fact, that energy is handled by different Ministries that have the primary responsibility of setting their own sectoral agenda, an omnibus policy is required to achieve the goal of energy security through coordination between these sources. This is also expected to mainstream emerging energy technologies, and provide consumer energy choices. The NEP builds on the achievements of the earlier omnibus energy policy

– the Integrated Energy Policy (IEP), and sets the new agenda consistent with the redefined role of emerging developments in the energy world.

A number of far-reaching developments have taken place in the local and global energy space which have to be reflected in our own policy framework. There is a need to support the trends which usher in efficiency by a pro-active policy. While steps have already been taken by the Government to embed many such developments in the sectoral energy policies, however, it is desirable to develop a clear roadmap so that there is clarity amongst all the stakeholders on the Government's long-term energy agenda. Long term investors, both on supply and demand sides, need clarity on stable energy policy outlook. The following global developments call for policy clarity:

A. Changes in Energy mixture:

The world is moving away from overwhelming dependence on fossil fuel, and within the fossil fuels, away from coal and oil in favor of gas. Against an 88% total share of fossil fuels globally in the primary energy mix in the year 2005, the same fell to 86% in the year 2015. The share of oil has in particular fallen from 36% to 33%, while that of natural gas has increased from 23% to 24%, and that of Renewable Energy (including nuclear and large hydro) has gone up from 12.5% to14% in the period 2005-15. The above trends, principally owing to climate change concerns, are expected to be maintained over the medium term.

B. Abundance in supply of natural gas:

The success of horizontal drilling combined with the technology of hydraulic fracture, has come to be established in the US where the production of natural gas went up from 511 BCM in 2005 to 767 BCM in 2015. This has boosted the already rising production of natural gas in the world from 2791 BCM in 2005 to 3539 BCM in the year 2015. As the price of gas is lower than that of oil, and is also one-third lesser as carbon emitting than oil, the ascendency of gas vis-a-vis oil is likely to continue in the near foreseeable future.

C. Oversupplied oil and gas markets:

Due to multiple reasons including the two factors listed above, along with other commodity prices, oil and gas prices have softened, and this is triggering energy policy reforms across the world. The prices of oil and gas have fallen by 50% and

70%, respectively over 2014. Many oil importing countries including India have been able to attempt bold petroleum pricing reforms, and are in a sound fiscal position to attempt larger energy policy reforms.

D. The maturities of renewable energy technologies:

The sharp decline in the prices of wind and solar technologies in the recent years by about 60% and 52% respectively between 2010 and 2015 (in kWh terms), has led to a change in the relative importance of energy sources. Tropical countries, including India, are richly endowed with the above resources, and can harness them in an innovative manner to meet energy requirements at decentralized locations. In the recent auctions, solar and wind energy prices have achieved bus bar grid parity at the generation end.

E. Climate change concerns:

The adverse effects of climate change are much more discernible than ever before, with a better understanding of the relationship between energy use and poor environmental outcomes. While the global agenda is of common concern, there is a heightened consciousness of the need to fix poor air quality standards in Indian cities, which is being reflected in tough administrative actions and court mandated orders.

All the above developments offer a challenge to the existing energy pathways, and also offer an opportunity to respond by building in sustainability in the new energy infrastructure. There is a raging debate as to whether the latter could be developed in a more decentralized manner. Whether or not the past global practice of large generation plants with capital intensive evacuation/transmission infrastructures, can now be better done with low cost decentralized solutions, the new energy pathways must be enabled to accept decentralized solutions. As per the energy modeling exercise undertaken by the NITI Aayog — India Energy Security Scenarios (IESS), 2047, the energy demand of India is likely to go up by 2.7-3.2 times between 2012 and 2040, with the electricity component itself rising 4.5 fold. India has an opportunity to incorporate emerging technologies in the new infrastructure, to be able to exploit these technologies as they mature and costs falls.

National Energy Mission: The National Energy Policy plans at supporting the Indian ambition to emerge as a well-developed and resilient economy with high level of human development. Additionally, it helps prepare the nation to anticipate the technological and market related changes in the energy sector. What will India's energy sector look like in 2040? India Vision 2040 aims to answer the above precise question. Demand-driven provision of energy at affordable prices, high per capita consumption of electricity and access to clean cooking energy and electricity with universal coverage, low emission and security of supply will characterize the energy parameters of India in 2040. The energy mix will also undergo a transformation with preponderance of renewable technologies, storage solutions, smart grids and enlightened consumer behavior becoming the order of the day. We attempt here to present the NITI Ambition Scenario (NAS) 2040 — energy in India in 2040 — the expected energy status of India, via the NEP. The NAS has been developed so as to provide a range of implications for the Indian energy sector. The range represents the outcome scenarios if India were to follow a business-as-usual path versus if it were to transition to an ambitious one — cleaner and more sustainable pathway. The policy mandate has to be linked to the latter.

The energy mix of India will have a high share of renewable which will sustain the present self-dependence scenario. India had imported nearly 31% of its primary energy in 2012, with 77% and 22% of oil and gas imports, respectively. The share of renewable (excluding biomass) was 3%. In 2040, with renewable comprising 7%-10% of India's energy mix, the overall import of primary energy is expected to rise substantially. Oil and gas imports will be responsible for the rise in imports, and are estimated to rise to 81-88% and 35-51%, respectively. Therefore, while registering a 2.7-3.2 times growth in energy supply, the country's dependence on overseas supply is expected to increase. On the other dimension of energy security, namely supply assurance, with widespread expansion of energy infrastructure, storage solutions and inter-connectors with other countries in the region, it is hoped that there will be high levels of confidence, devoid of supply threats. Even technology is expected to play a major role, as the share of electricity in final energy will have risen to 23-26% in 2040 against 17% in 2014, with almost all demand sectors becoming amenable to its use. We are aware that power supply is inherently a more dependable source due to its inter-connectedness and also due to local deployment of renewable electricity.

Equity: Increased urbanization and rural transformation will have by and large removed the developmental distance between the rural and urban settings. The modelling assumes similar levels of per capita energy consumption in rural and uraban areas by 2031-32. While their energy consumption parameters may be different, but rural areas would not lack commercial sources of energy. Solid biomass is expected to be replaced by liquid and gaseous fuels and electric cooking will be a major practice across the country. Around 30% of the rural households will remain dependent on solid biomass for cooking. As mentioned earlier, electricity will be the major form of energy use and the large off-grid renewable agenda will contribute significantly to its widespread availability. Market framework will address the issues of delivery mechanism, which are presently a major challenge for the public sector agencies.

Affordability: The pricing, subsidy and affordability aspects of energy supply will undergo the most dramatic change of all. The country will have transitioned to direct benefit transfer (DBT) to the meritorious, and also make it possible for the vulnerable sections to exercise choice in procuring their preferred source of energy. This will further promote markets and competition, which will have become the norm in the larger context. The IESS 2047 modelling exercise reveals that the transition to cleaner energy in the case of India Vision 2040, will be a cheaper pathway than the default one in terms of consumer spends, however, capital intensive. Without the7%-11% share of commercial energy coming from renewable sources, Indian energy market would have become more dependent on global volatile energy markets (imports have the potential to reach 41-59% of primary commercial energy in 2040 from 36% in 2012, depending on the pathway that the economy follows). Hence, competitive markets, combined with higher share of cheaper renewable sources and efficient subsidy delivery mechanism, will make energy affordability a non-issue.

Energy mix: In an increased electricity share, while in the immediate run-up towards universal coverage of electricity it may not be viable to tap rooftop solar for homes, but by 2040 it would have become the norm. The share of solar and wind is expected to be 14-18% and 9-11% in electricity, and 3-5% and 2-3% in the primary commercial energy mix respectively. The advent of EVs will have helped curb a rise in share of oil and environment friendly gas would substitute oil in many uses. However, the share of oil and gas would have almost maintained their shares of 26% and 6.5% in 2015-16 to 25-27%

and 8-9% in 2040, respectively. In spite of a more than three times increase in gas consumption, owing to large increase in total energy, the increase in gas would be less in percentage terms. While coal would have risen in absolute terms (nearly double), but in relative terms, it would have reduced its contribution from 58% in 2015 to 44-50% in 2040. The overall share of fossil fuels would have come down from 81% in 2012 to 78% in ambitious pathway in 2040.

Energy markets: In 2040, the Indian energy market will have fully evolved with supply rising to meet demand on the basis of competitive markets. The trend of rising private sector share in supplies of electricity, oil, gas, coal, and renewables — both in production and trade — will transform the market by 2040. The market size will be nearly 2.7- 3.2 times the present, and public sector's contribution will have been much reduced, other than in coal production and nuclear power. The latter will be an outcome of the statutory provisions reserving the public sector's business, rather than of the economics of these sectors. As subsidies will be in cash rather than in kind, the private sector will also be able to deliver energy to the targeted sections of the society, and be an active participant of subsidy schemes. So far, subsidized energy delivery has in parts been reserved for the public sector. India will be integrated with global energy markets and be an active energy trader with its neighbors, including central and west Asian ones. Long term energy supply contracts will be the norm, and prices will be aligned with international ones.

Structure of the Industry: The present scenario of energy companies specializing in their sub-sectors is expected to undergo a change, with companies integrating both forward and backward. With increased globalization, emergence of mega-super majors will threaten national companies, leading to amalgamations in the latter space, too. As the share of electricity is likely to increase from 17% in 2014 of energy demand to near 23-26%, there will be a natural tendency of integration (both forward and backward) for energy producers (coal, oil and gas) to tap the power market and become generators, just as power producers are trending towards picking up coal mines. In later years, as generation/refining plateaus, there will be a tendency to move towards distribution as well. This will also lead to consolidation and emergence of large integrated energy players, reaping the economies of scale afforded by the large energy market. The role of markets having become manifest, energy will be freely traded and competition will achieve benefits for the customers. The local endowment of energy resources will influence the energy mix in nearby markets as will be witnessed in the north and north east, where hydel power may play an important role. The coastal south and west India, being close to the oil/gas rich West Asia, will witness a more significant role of LNG, including imported coal based plants. However, the emergence of a robust national electricity grid will ensure a single power market.

Infrastructure: Enhanced energy supply will require a large expansion in energy infrastructure along the entire value chain, and will have been created during the period up to 2040. Just as the country is going in for optic fibre backbone across the country, gas pipelines and electric transmission lines will have net-worked the entire country. LNG terminals, city gas distribution grids, strategic and commercial oil and gas storages, renewable energy projects (both grid connected and rooftop) will have sprung up to deliver energy to all parts of India. India has the advantage of offering a new market, for which latest technology will be the norm in infrastructure creation. It is acknowledged that it is more cost effective to adopt latest technology when building new rather than retrofitting, which is the case in the West. The advent of new technology and cost reduction in storage options (battery among others), will facilitate exploitation of the abundant renewable resource. The near 30-35% share of renewable energy in electricity mix will see a different kind of infrastructure — distributed and decentralized — than the capital intensive and centralized ones that exist in the West.

Government as an animator of markets: The Government will have gradually moved into the role of a facilitator rather than an active player. Energy will be sourced from wherever necessary, domestic or imported sources, and sold at market prices. The Government, directly and through its agents — PSUs and Regulators — will help create the conditions for suppliers and demanders to meet in the market. The role of Government as a welfare state will be carried out efficiently, by not loading the subsidies on businesses, but through its own coffers where necessary. It may even socialise costs. In some processes, such as technology development, R&D, HRD and infrastructure, Government may step in to reduce capital risks both by policy interventions and providing seed capital, but will otherwise remain an animator rather than an active participant. The large apex of $3.6 trillion in the energy sector upto 2040 (IEA) will be a major target to strive for by the Indian policy makers. This translates into nearly $150 billion per year, mostly in the electricity sector, which is a quantum jump from the present. The above scenario will be realized by 2040 with energy being a major contributor to, and a recipient of support from, other economic sectors.

The NEP assumes a high GDP growth rate for India between now and 2040, and an equally high adoption rate of energy efficient measures. Hence, while there will be a significant growth in energy demand, but the energy intensity will be much lesser than now. This will be consistent with our NDCs. The large Indian energy market will drive competition between sources of energy and also within the same source. The role of markets in lowering the price of solar and wind energy and LED bulbs has already been witnessed, as has the role of markets in driving technology been recognized in the exploitation of shales in the US, through horizontal drilling and hydraulic fracture. Smart grids and storage solutions hold a great future for a country like India that wishes to achieve a large share of renewable electricity. Therefore, markets and technology are expected to define the energy scenario of India in 2040, called the NITI Ambition Scenario (NAS), 2040.

Monitoring and Coordination Mechanism: The NEP envisages interventions across multiple Ministries, over an extended period of time. This will call for a standing arrangement for overseeing its implementation. A twin mechanism will be created to monitor progress of the proposals contained in the NEP, and also coordinate the efforts of different Ministries. A Steering Committee comprising of Ministers of the relevant Ministries chaired by the Prime Minister will be created to review the progress of implementation. This would be serviced by the NITI Aayog. The second Committee to help in inter-ministerial coordination towards implementing the proposals would comprise Secretaries in the relevant Ministries, would be chaired by the CEO, NITI Aayog.

There are four key objectives of energy policy:

Access at affordable prices: Considering poverty and deprivation in India, access to energy for all at affordable prices is of utmost importance. India is yet to provide electricity to almost 304 million people, and clean cooking fuel to nearly 500 million people, which still depend on Bio-energy. The National Policy on Energy aims to ensure that electricity reaches every household by 2022 as promised in the Budget 2015-16 and proposes to provide clean cooking fuel to all within a reasonable time. While it is predicted that financial support will be extended to ensure merit consumption to the vulnerable sections, competitive prices will drive affordability to meet the above aims.

Improved security and Independence: Improved energy security, normally associated with reduced import dependence, is also an important goal of the policy. Today, India is heavily dependent on oil and gas imports while also importing coal. In so far as imports may be disrupted, they undermine energy security of the country. Energy security may be enhanced through both diversification of the sources of imports and increased domestic production and reduced requirement of energy. Given the availability of domestic reserves of oil, coal and gas and the prospects of their exploitation at competitive prices, there is a strong case for reduced dependence on imports. In due course, we may also consider building strategic reserves as insurance against imported supplies.

Greater Sustainability and Economic Growth: The goal of sustainability acquires added importance and urgency in view of the threat of catastrophic effects of climate change as well as the detrimental effects of fossil fuel usage on local air quality. In India, sustainability is also closely linked with energy security. Our fossil fuel requirements, which comprise nearly 90% of our commercial primary energy supply, are increasingly being met by imports. This means that cutting fossil fuel consumption would promote the twin goals of sustainability and security. Hence the policy lays heavy emphasis on de-carbonisation through the twin interventions of energy efficiency and renewable energy.

Support the goal of rapid economic growth: Finally, the energy policy must also support the goal of rapid economic growth. Efficient energy supplies promote growth in two ways. First, energy is the lifeblood of the economy. It is an important enabling factor of growth and its availability at competitive prices is critical to the competitiveness of energy-intensive sectors. Second, being a vast sector in itself, its growth can directly influence the overall growth in the economy. For example, petroleum products have been an important direct contributor to our growth in recent years by attracting large investments in refining/distribution, and also fuelling economic activity.

8.2.2. National Biofuel Policy

National Policy on Biofuel was made by **Ministry of New and Renewable Energy** during the year **2009**. This policy was developed to promote **biofuels** in India, Globally, biofuels have trapped the attention in last decade and it is vital to keep up with the pace of developments in the field of biofuels. Biofuels in India are of strategic importance as it augers well with the ongoing initiatives of the Government such as **Make in India**, **Swachh Bharat Abhiyan**, **Skill Development** and offers great opportunity to integrate with the ambitious targets of doubling of Farmers Income, Import Reduction, Employment Generation, Waste to Wealth Creation. Programmes related to biofuels in India have been largely impacted due to the sustained and quantum non-availability of domestic feedstock for biofuel production which needs to be addressed. The **Union Cabinet**, chaired by the Hon'ble Prime Minister **Shri Narendra Modi** has approved National Policy on Biofuels – **2018**.

Salient Features of National Biofuel Policy: There are salient features of National Biofuel Policy which are given below:

- The Policy categorises bio-fuels as "Basic Bio-fuels" viz. First Generation (1G) bio-ethanol & biodiesel and "Advanced Bio-fuels" - Second Generation (2G) ethanol, Municipal Solid Waste (MSW) to drop-in fuels, Third Generation (3G) bio-fuels, bio-CNG etc. to enable extension of appropriate financial and fiscal incentives under each category.
- The Policy expands the scope of raw material for ethanol production by allowing use of Sugarcane Juice, Sugar containing materials like Sugar Beet, Sweet Sorghum, Starch containing materials like Corn, Cassava, Damaged food grains like wheat, broken rice, Rotten Potatoes, unfit for human consumption for ethanol production.
- Farmers are at a risk of not getting appropriate price for their produce during the surplus production phase. Taking this into account, the Policy allows use of surplus food grains for production of ethanol for blending with petrol with the approval of National Biofuel Coordination Committee.
- With a thrust on Advanced Biofuels, the Policy indicates a viability gap funding scheme for 2G ethanol Bio refineries of Rs.5000 crore in 6 years in addition to additional tax incentives, higher purchase price as compared to 1G biofuels.
- The Policy encourages setting up of supply chain mechanisms for biodiesel production from non-edible oilseeds, Used Cooking Oil, short gestation crops.

- Roles and responsibilities of all the concerned Ministries/Departments with respect to biofuels has been captured in the Policy document to synergies efforts.

Benefits of National Biofuel Policy: There are various benefits of national biofuel policy which are summarized in Figure 1 and also described below:

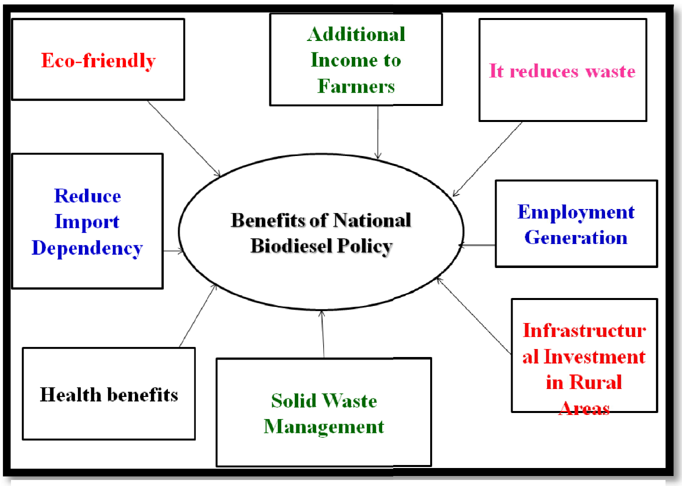


Figure 1. Expected benefits of the National Biodiesel Policy

Reduce Import Dependency: It is one of the best benefits of the national biodiesel policy. One crore lit of E10 saves Rs.28 crore of forex at current rates. The ethanol supply year 2017-18 is likely to see a supply of around 150 crore litres of ethanol which will result in savings of over Rs.4000 crore of forex.

Environmental friendly: National Biodfuel policy has environmental friendly benefits. It is estimated that one crore lit of E-10 saves around 20,000 ton of CO2 emissions. For the ethanol supply year 2017-18, there will be lesser emissions of CO2 to the tune of 30 lakh ton. By reducing crop burning & conversion of agricultural residues/wastes to biofuels there will be further reduction in Green House Gas emissions.

Health benefits: Prolonged reuse of Cooking Oil for preparing food, particularly in deep-frying is a potential health hazard and can lead to many diseases. Used Cooking Oil is a potential feedstock for biodiesel and its use for making biodiesel will prevent diversion of used cooking oil in the food industry.

Augment waste to wealth: It is estimated that, annually 62 MMT of Municipal Solid Waste gets generated in India. There are technologies available which can convert waste/plastic, MSW to drop in fuels. One ton of such waste has the potential to provide around 20% of drop in fuels.

Infrastructural Investment in Rural Areas: It is estimated that, one 100klpd bio refinery will require around Rs.800 crore capital investment. At present Oil Marketing Companies are in the process of setting up twelve 2G bio refineries with an investment of around Rs.10,000 crore. Further addition of 2G bio refineries across the Country will spur infrastructural investment in the rural areas.

Employment Generation: One 100klpd 2G bio refinery can contribute 1200 jobs in Plant Operations, Village Level Entrepreneurs and Supply Chain Management.

Improve Farmers Income: By adopting 2G technologies, agricultural residues/waste which otherwise are burnt by the farmers can be converted to ethanol and can fetch a price for these waste if a market is developed for the same. Also, farmers are at a risk of not getting appropriate price for their produce during the surplus production phase. Thus conversion of surplus grains and agricultural biomass can help in price stabilization. The biofuel supply chain create a circular rural economy that results in substaintial environmental, socio economic and health benefits as stated earlier. The money so generated may be ploughed back to rural economy.

8.3. Climate Change

Climate change is a change in the pattern of weather and related changes in ocean, land surfaces and ice sheets, occurring over time scales on decades or longer. Weather is the state of the atmosphere- its temperature, humidity, wind, rainfall and so on over hours to weeks. It is influenced by the oceans, land surface and ice sheets which together with the atmosphere form what is called the climate system. Climate in its broadest sense is the statistical description of the state of climate system, that persists for several decades or longer, usually at least 30 years. These statistical properties include averages, variability and extremes. Climate change may be due to natural process or due to human influences.

8.3.1. Causes of Climate Change

There are many reasons of climate change which can be grouped as:

a) Natural
b) Manmade (human) reasons

Natural Causes: These include volcanic eruptions, solar radiation, tectonic plate movement and orbital variations. Due to such natural phenomena geographical condition of an area become quite abnormal for life to survive.

Human Causes: Humans are increasingly influencing the urban/ industrial waste, transportation and overexploitation of natural resources (Figure 2). These activities add enormous quantity of green house gases to those naturally occurring in the atmosphere increasing the green house effect and global warming. These causes are further sub categorized as :

Transportation: The vehicles are powered by the fossil fuel. As the fossils fuel burn they release carbon dioxide and other gases in atmosphere which change the climate significantly.

Industrialization: The transition of economies from agriculture to industries led in to climate change. As you know that industries release green house gases in atmosphere which cause global warming, green house effects and ozone layer depletion.

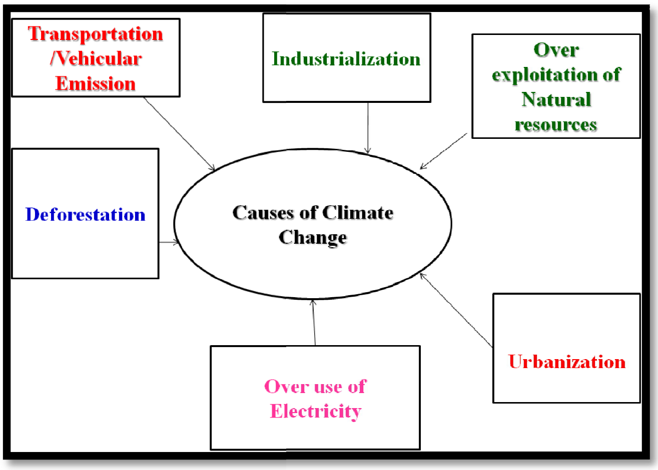


Figure 2 Causes of climate change

Deforestation: Plants are the most important absorber of carbon di oxide. As you know that deforestation is clearing of trees for non-agriculture or non-planting purpose. As population raises, requirements of buildings, school, hospitals, roads also increases. Due to deforestation carbon di oxide stored in plants is converted to reactive CO2 in the atmosphere which is responsible for climate change.

Over use of electricity: Overuse of electricity also leading in to climate change at global and local levels. Overuse of electricity can make burden on the natural resources. As you know that electricity is the main source of the power specially in urban areas. All our gadgets run due to electricity generated mainly from thermal power plants and thermal power plants run on fossil fuels and responsible for large amount of green house gases and other pollutants.

8.3.2. Impacts of Climate Change

Climate change presents significant challenge to human health and biodiversity. Increased number of extreame climate events such as heat waves, droughts or flodings threaten human health and well beings both directly and indirectly through paired ecosystem functioning and reduced ecosystem services. The important impacts of climate change are shown in figure 3 and discussed below in details:

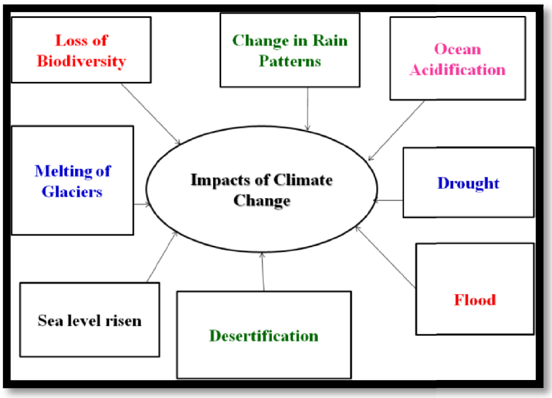


Figure 3 Impact of climate change

Melting of Glaciers: It is one of the most important impacts of climate change. Climate change certainly leads in to rising temperature of the earth, which can melt the glaciers. It is estimated that Arctic ice could completely melt during the hottest period of the year by the end of the century. As you know that cryosphere (area where ice deposited in the form of glaciers) naturally plays an important role in global climate system and change in its extension could cause a change in system itself.

Sea level Rise: Climate change also leads in to rise in sea level. As per report of Intergovernmental Panel on Climate Change (IPCC) melting ice lands in Antarctica and Greenland have most likely led sea level to rise by 3.1 millimeters per year between the years 1993-2003. The sea level is expected to reach 15-95 centimeters by 2010.

Ocean acidification: Climate change and global warming also responsible to acidification of ocean at global level. Increased level of CO_2 in the atmosphere will also lead to ocean acidification, causing irreparable damage to marine ecosystem. The Great Barrier Reef is best example of ocean acidification.

Desertification: Climate change also leads in to desertification. Desertification will expand the areas that currently boast a temperate climate such as the area north and south of the Sahara desert, including the Mediterranean countries, causing severe damage to agricultural industry. Productivity of crop significantly decline while more and more population will face undernourishment. In particular, yields from maize and wheat crop could drop by 50% over the next 30 Years due to climate change. It's a risk that to be prevented considering that people suffering from hunger are presently slightly decreasing.

Events like El Nino (A variation in the southern oscillation that causes significant changes in climate). These types of events certainly rising due to climate change which can cause economical losses, diseases etc.

Loss of Biodiversity: As you know that biodiversity is variety and variability among the living organisms from all types of ecosystems. Climate change severely affects the biodiversity at all possible levels. Increasing in temperature certainly responsible for the population decline of millions of species.

Shifting in rain patterns: Climate change also changes the pattern of the rain. As you see many areas of India receives minimum rain on the other hand some areas receives more than average which can cause drought and flood like conditions in country.

8.3.3. Policies and agreements related to Climate Change

Climate change is a global problem and require global corporation to address. The objective of the United Nations Framework Convention on Climate Change (UNFCC) which virtually all nations, including Indian and US have ratified is to stabilize greenhouse gases (GHG) concentration at a level that will not cause dangerous anthropogenic (human induced) interference with the climate change. India announced its **National Action Plan on Climate Change** (NAPCC) in the year 2008. When it happened, we were just one of the 10-odd countries in the world to have a consolidated policy instrument to tackle climate change. Ten years later, and with the monsoon being even more erratic, there is no clarity on how NAPCC has fared. It is also true that India is now more vulnerable to climate change. According to the **Global Climate Risk Index of 2018**, published by **German Watch**, a non-profit working on North-South equity and preservation of livelihoods, India is the **12th** most vulnerable country to **climate change impacts**. Every year, it witnesses an average of **3,570** deaths attributable to climate-related **events**, and the cost of climate change impact it will pay is projected to run into trillions of dollars in the near future. For a country that has already been suffering from climate change impacts, the formulation of a policy to tackle the problem should have come in natural course. .

But NAPCC was more an exercise to secure international standing than anything else. The first decade of the 21st century was a period of great churning in terms of the political and economic discussions around climate change. Though there was no institutional pressure, developed countries were badgering developing countries to reduce their emissions. In

2007, China released its national plan to address climate change issues, leaving India as the only big developing country without such an instrument. As a result, the government wanted a policy instrument before the G8 Summit at Tokyo in 2008 and the Conference of Parties at Copenhagen in 2009. To this end, the United Progressive Alliance (UPA) government constituted the Prime Minister's Council on Climate Cha-nge (PMCCC) in mid-2007. The 26-member council included ministers, independent experts and retired government experts. Over three high-powered sessions, between July 13, 2007 and June 2, 2008, the government managed to announce NAPCC a month before the G8 summit to be held in July 2008. The plan, which has eight sectoral missions, was to be overseen by six Union ministries. However, overall 10 ministries, including finance and external affairs, too, were involved in its implementation. The rushed manner in which NAPCC was formulated ensured that the document merely provided broad objectives and did not address strategy. While PMCCC had representation of diverse sectors on paper, the document's content was primarily shaped by a three-member group from within the council—the principal scientific advisor, former secretary to the then Union Ministry of Environment and Forests, and the director general of Delhi-based non-profit The Energy and Resources Institute (TERI). The final draft was prepared by the Prime Minister's Office, further limiting the significance of inputs from the council.

Following the hurried announcement of NAPCC in 2008, the ministries concerned took six more years to approve the missions. By then, the new National Democratic Alliance (NDA) government had formed in 2014. Under the new dispensation, PMCCC has met, reportedly, just once in 2105. Though the government has announced new schemes to meet the climate change objectives, it has not aligned or integrated them with NAPCC. Due to this, the missions have lost homogeneity and functionality. There are several other challenges that the missions face. One, the monitoring system is either absent or ineffective. Two, the budgetary support by the government is very limited. Considering the scant domestic and international channels for finance, the government needs to mobilise funds from different sources. Three, states have to frame their own action plans, or State Action Plans on Climate Change (SAPCC), in line with NAPCC. But SAPCCs framed by almost all the states are vague.

The Kyoto Protocol legally binds developed country parties to reduce green house gases emission. There are now 197 parties to the convention and 192 parties to the Kyoto protocol.

At the 21st conference of the parties in Paris in 2015, parties to UNFCCC reached a landmark agreement to combat climate change and to accelerate and intensify the actions and investments needed for a sustainable low carbon future. The Paris agreement builds upon the convention and for the first time brings all nation in to a common cause to undertake take a ambitious efforts to combat climate change and adapt to its effects, with enhance support to assists developing countries to do so. The main aim of Paris agreement is to strengthen the global response to the Climate Summit in 2019.

8.4. Summary

In this unit we have discussed various aspects of Energy policies and climate change. So far you have learnt that:

- ***Demand of energy is increasing day by day at local and global level, therefore its conservation is the need of hour. Almost every nation conserves the energy and already made different policies for the conservation of energy.***
- ***Every policy which is emphasized on the conservation of energy is called energy policy. The energy policy is the process in which energy production, consumption, distribution have been decided by the Governments.***
- ***The National Energy Policy (NEP) is an extensive scale policy covering the whole national energy system in India. The policy focuses on two time horizons: near-term to 2022, and medium-term to 2040.***
- ***The National Energy Policy (NEP) focuses to chart the way forward to meet the Government's recent bold announcements in the energy domain. All the Census villages are planned to be electrified by 2018, and universal electrification is to be achieved, with 24x7 electricity by 2022.***
- ***The National Energy Policy plans at supporting the Indian ambition to emerge as a well-developed and resilient economy with high level of human***

development. Additionally, it helps prepare the nation to anticipate the technological and market related changes in the energy sector.

- ***National Policy on Biodiesel was made by Ministry of New and Renewable Energy during the year 2009. This policy was developed to promote biofuels in the India, Globally, biofuels have trapped the attention in last decade and it is vital to keep up with the pace of developments in the field of biofuels. Biofuels in India are of strategic importance as it augers well with the ongoing initiatives of the Government such as Make in India, Swachh Bharat Abhiyan, Skill Development and offers great opportunity to integrate with the ambitious targets of doubling of Farmers Income, Import Reduction, Employment Generation, Waste to Wealth Creation.***
- ***There are various benefits of national biodiesel policy which are Reduce Import Dependency, Environmental friendly, Health benefits, Solid Waste Management, Infrastructural Investment in Rural Areas, Employment Generation, Additional Income to Farmers etc.***
- ***Climate system in made up of five different interacting parts viz. atmosphere, hydrosphere, cryosphere, biosphere and lithosphere.***
- ***Climate change happens when changes in earth's climate system. NASA defines climate changes as "A broad range of global phenomena created predominately by burning fossil fuels, which add heat trapping gases to earth atmosphere.***
- ***There are various causes of climate change such as transportation, industrialization, deforestation, over use of electricity etc.***
- ***There are various impacts of climate change on environment, human health and biodiversity melting of Glaciers, sea level Rise, ocean acidification, desertification, loss of Biodiversity and shifting in rain patterns.***
- ***There are various policies have been implemented at national and global level. India announced its National Action Plan on Climate Change (NAPCC) in the year 2008. When it happened, we were just one of the 10-odd countries in the world to have a consolidated policy instrument to tackle climate change.***

- ***The Paris agreement builds upon the convention and for the first time brings all nation in to a common cause to undertake take a ambitious efforts to combat climate change and adapt to its effects, with enhance support to assists developing countries to do so. The main aim of Paris agreement is to strengthen the global response to the***
- ***Climate Summit in 2019***

TERMINAL QUESTIONS

1 (a) Fill in the blank spaces with appropriate words.

National Policy on Biofuels was made by Ministry of …………………..during the year………. This policy was developed to promote biofuels in the India, Globally, biofuels have caught the attention in last decade and it is imperative to keep up with the pace of developments in the field of………. Biofuels in …..are of strategic importance as it augers well with the ongoing initiatives of the Government such as Make in India, Swachh Bharat Abhiyan, Skill Development and offers great opportunity to integrate with the ambitious targets of doubling of Farmers Income, Import Reduction, Employment Generation, Waste to Wealth Creation. Biofuels programme in India has been largely impacted due to the ……………and quantum non-availability of domestic feedstock for biofuel production which needs to be addressed. The Union Cabinet, chaired by the …………………has approved National Policy on Biofuels – 2018.

2. (a) Why energy policies are needed? Explain in brief.

(b) What is National Energy policy? Explain

3. (a) Describe the National biodiesel policy.

(b) What are salient features of National Biodiesel policy.

4. a) Write about benefits of National biodiesel policy.

5. (a) Discuss key features of National energy mission.

6 (a). **Fill the blank spaces with appropriate words.**

…………. …….. …….. …….. ……… …………. (NAPCC) in the year………. When it happened, we were just one of the 10-odd countries in the world to have a consolidated policy instrument to tackle climate change. Ten years later, and with the monsoon being even more erratic, there is no clarity on how NAPCC has fared. It is also true that India is now more vulnerable to climate change. According to the……………. ……… ………. …….. of 2018 published by German Watch, a non-profit working on North-South equity and preservation of livelihoods, India is the ……….most vulnerable country to climate change impacts. Every year, it witnesses an average of …………deaths attributable to climate-related…………., and the cost of climate change impact it will pay is projected to run into trillions of dollars in the near future. For a country that has already been suffering from climate change impacts, the formulation of a policy to tackle the problem should have come in natural course.

(b) Kyoto protocol is related to (Reduction in green house gases/Preservation of ozone layer/Economic development/None of these)

(c) Main aim of Paris agreement was (Conventional energy/Non-conventional energy)

(d) What do you understand by climate change?

(a) Discuss causes of climate change on environment.

(b) Describe the impacts of climate change.

(c) Explain the policies and initiative with respect to climate change.

ANSWERS

1 (a) New and Renewable Energy, 2009, biofuels, India, sustained, Prime Minister,
2 (a) see section 8.2., 8.2.1. and introduction of this unit.
(b) See section 6.2 under heading National energy policy.
3 (a) See section 8.2.2.
(b) See section 8.2.2. under heading salient features of National Biodiesel policy.
4 (a) See section 8.2.2 under heading benefits of National Biodiesel policy including Fig.1.
5 (a) See the section 8.2.1 under heading National Energy mission
6 (a) National, Action, Plan, on, Climate, Change, 2008, Global, Climate, Risk, Index, 12th, 3,570, events,
(b) Reduction in green house gases
(c) Conventional energy
(e) See the section 8.3.
7 (a) See the section 8.3.1.
(b) See the section 8.3.2.
(c) See the section 8.3.3.

UNIT-9: ENERGY CONSERVATION I: DEMAND MANAGEMENT, IMPROVING EFFICIENCY

Unit Structure

9.0 Learning Objectives

After studying this unit you will be able to understand:

- To develop understanding with respect to energy conservation.
- Energy demand and its status at global and national levels.
- About demand management
- About technologies related to improving energy efficiencies.
- To develop understanding on climate change and mitigation.

9.1. Introduction

Energy conservation is the desion and practice of using less energy. Energy needs to be conserved not only to cut costs but also to preserve the resources for longer use. As you know that demand of energy is increasing day by day and consequently it can leads degradation of natural resources. Energy production may be done by the hydropower, coal, fossils fuel, biomass, tidal, solar, geothermal etc. The demand of energy increases with increase in population. Energy is used in every developmental sector. Therefore, conservation of energy is need of hour. Energy conservation is vital and plays significant role in mitigating climate change. Energy conservation refers to efficient use of energy at home and replacement of non-renewable resources (Coal, petroleum, fossil fuel etc) with renewable energy resources like Solar, tidal, geothermal and biomass etc.. As you know that we have very limited amount of non-renewable energy resources available on the earth, therefore it is very important to conserve energy from our current sources or to utilize renewable energy sources. We also should focus on improving technologies for conservation of energy. In this unit you will learn about energy demand at global and national level, improving technologies related to energy.

9.2. Meaning of Energy Conservation

Energy conservation is the practice of reducing the quantity or amount of energy used. Energy conservation may result in increase of financial growth, better eco-friendly results, national security and personal security etc. Today almost every nation of the world looking for new technologies by which energy can be conserved.

9.3. Energy Demand

Energy demand is the term used to describe the consumption of energy by human activity.

Energy demand management, also known as **demand-side management** (**DSM**) or **demand-side response** (**DSR**), is the modification of consumer demand for energy through various methods such as financial incentives and behavioral change through education.

Usually, the goal of demand-side management is to encourage the consumer to use less energy during peak hours, or to move the time of energy use to off-peak times such as nighttime and weekends. Peak demand management does not necessarily decrease total energy consumption, but could be expected to reduce the need for investments in networks and/or power plants for meeting demand at its highest. An example is the use of energy storage units to store energy during off-peak hours and discharge them during high demand hours. A newer application for DSM is to aid grid operators in balancing intermittent generation from wind and solar units, particularly when the timing and magnitude of energy demand does not coincide with the renewable generation.

Objective:

Electricity use can vary dramatically on short and medium time frames, depending on current weather patterns. Generally the wholesale electricity system adjusts to changing demand by dispatching additional or less generation. However, during peak periods, the additional generation is usually supplied by less efficient sources. Unfortunately, the instantaneous financial and environmental cost of using these efficient sources is not necessarily reflected in the retail pricing system. In addition, the ability or willingness of electricity consumers to adjust to price signals by altering demand may be low, particularly over short time frames. In many markets, consumers, (particularly retail ones) do not face real-time pricing at all, but pay rates based on average annual costs or other constructed prices.

Energy demand management activities attempt to bring the electricity demand and supply closer to a perceived optimum and help to give electricity end users benefits for reducing their demand. In the modern system, the integrated approach to demand-side management is becoming increasingly common.

Foundation of energy management:

Demand for any commodity can be modified by actions of market players and government. Energy demand management implies actions that influence demand for energy. DSM was originally adopted in electricity, but today it is applied widely to utilities including water and gas as well.

Reducing energy demand is contrary to what both energy suppliers and governments have been doing during most of the modern industrial history. Whereas real prices of various energy forms have been decreasing during most of the industrial era, due to economies of scale and technology, the expectation for the future is the opposite. Previously, it was not unreasonable to promote energy use as more copious and cheaper sources could be anticipated in the future or the supplier had installed excess capacity that would be made more profitable by increased consumption.

In centrally planned economies subsidizing energy was one of the main economic development tools. Subsidies to the energy supply industry are still common in some countries.

Contrary to the historical situation, energy prices and availability are expected to deteriorate. Governments and other public actors, if not the energy suppliers themselves, are tending to employ energy demand measures that will increase the efficiency of consumption.

9.3.1. Energy Demand at National Level

In relation to its population, India is poorly endowed with energy resources. India accommodate world population of 17% but occupies world gas, oil and coal reserves only 0.6%, 0.4% and 7%, respectively and hence, heavy dependence on imports even at a rather low level of energy consumption. It is surprising that despite this severe supply constraint, only recently this country has started to paying serious attention to demand-side interventions that would help to economize on the use of energy. There are at least two demand-side interventions that can help cut energy usage: behavioral change that results in reducing the demand for energy-based service and the introduction of alternatives that maintain the level of service but reduce the energy required for its provision. The former is called energy conservation and the latter is energy efficiency. An example of energy conservation is the shift to fan from air-conditioning, which cuts the need for energy by lowering the level of service received. Similarly, an example of improved energy efficiency is the shift to LED bulbs from regular bulb, which maintains the service but cuts energy consumption. Often conservation and efficiency effects come jointly. For example, when houses are designed to allow better flow of air and the use of air-conditioning is foregone, there is partial decline in service (comfort level) indicating both conservation and efficiency.

The recently adopted Nationally Determined Contributions (NDCs) as signatory to the United Nations Framework Convention on Climate Change (UNFCCC) emphasize the importance of demand side factors. In its submission, India gave particular importance to behavioural change leading to energy conservation, something that has received insufficient attention in the developed countries. The NEP aims to internalize this shift in our energy policy.

Energy consumption in India is characterized by low per capita level and a large disparity between urban and rural areas. In 2015-16, our per capita energy and electricity consumption at 670 kgoe (Kilogram of oil equivalent) and at 1075 KWh annually, respectively, are just one third of the world average. Nearly 25% of our population today is without access to electricity and 40% do not have access to clean cooking fuel. In 2014, the share of electricity in final energy demand was only 17% compared with 23% in the member countries of Organization for Economic Cooperation and Development (OECD). This low share means that a large proportion of energy consumption takes the form of solid and liquid fuels, exacerbating the air quality at the demand centres. Because electricity has the virtue of delinking emission from the point of consumption, for many uses, it is a preferred form of energy.

Energy Security Scenarios of India

Energy Security Scenarios allows us to predict energy consumption in the final year of the policy, 2040, under alternative scenarios with respect to efforts towards achieving greater energy efficiency. In Table 1, you can see these estimates under a range of two sets of assumptions: a baseline effort and a significantly more ambitious effort towards achieving energy efficiency and conservation. The baseline and ambition scenario generates the higher demand and lower bounds.

With the GDP composition across different sectors changing with growth, energy shares of consuming sectors shift. Buildings, industry and transport sectors together are the main gainers in both scenarios. But the gains of individual sectors vary considerably in the two scenarios. The maximum efficiency gains accrue in transportation sector whose share in the total energy consumption in 2040 turns out to be 23% under the ambitious compared with 25% in the baseline scenario.

The most dramatic shift occurs in the cooking sector. Here we see environmentally cleaner energy replacing the current biomass fuels. Energy share of cooking drops from 22% in

2012 to just 3.3% in 2040 in the baseline case and 3.5% in the ambitious scenario. From health perspective, this is a most valuable shift.

Table-1: Actual and projected energy consumption under alternative scenarios.

Sectors	**Actual**	**Projected**			
	2012	**2022**		**2040**	
TWh		BAU	Ambitious	BAU	Ambitious
Buildings	238	568	525	1769	1460
Industry	2367	4010	3600	8764	7266
Transport	929	1736	1628	3828	3243
Pumps & tractors	237	423	388	728	592
Telecom	83	131	124	207	164
Cocking	1072	829	684	524	467
Total	4926	7697	6949	15820	13192
% reduction in energy demand in 2040	17%				

Towards Energy Efficiency and Conservation Policy

The National Mission for Enhanced Energy Efficiency (NMEEE), launched under the National Action Plan on Climate Change (NAPCC) could not achieve its intended goals due to poor inter-sectoral linkages. The experiences gained indicated that energy efficiency programmes cannot be run on a stand-alone basis and require close coordination between energy supplying and consuming sectors, as well as with technology development, management apparatus and finance streams. A revamped National Mission would be launched which would have stronger linkage than before between the related sectors, and provide for a robust supervisory and review mechanism.

The adoption of efficient practices across all energy consuming sectors calls for a well-planned strategy with four specific components:

- First, the policy objectives need to be clearly identified which would lead to the right implementation strategy.
- Second, the regulatory and statutory mechanisms need to be made robust so that along with consumer preferences, even the manufacturing and trade sectors conform to state of the art technology and energy practices.
- Third, choosing the right intervention tools and programmes will be an important component of this strategy.
- Finally, a robust institutional mechanism ought to be created which can evaluate, monitor and promote a nation-wide energy efficiency programme.

Setting Objectives

Energy efficiency programmes ought to be evaluated against set targets which requires a robust data base. In order to develop a baseline status of energy efficiency in different demand sectors, the Bureau of Energy Efficiency (BEE) would conduct a study directly or by an out-sourced agency. The scope of the study would include all energy demand sectors of the economy and extend to existing processes and technologies, level of energy efficiency, readiness to move to more energy efficient technologies, current cost considerations, level of skillets' and upgradation of skills with advancement in technologies.

The BEE would specifically look at convergence with existing national programmes and plan appropriate interventions like 100 Smart Cities, Housing for All by 2022, Power for All by 2022, 175 GW of renewable energy by 2022 etc. to achieve synergy. The initiatives such as Smart Cities and solar pumps should mandate using only the most efficient appliances.

Energy Supply

Fossil Fuel Based Energy Supply (Oil and Gas)

Because oil and gas are generally found jointly, policy discussions often focus on them jointly. Due to a number of differentiators, including carbon content per unit of heat, more gas availability and lower cost in calorific terms, today gas is preferred to oil. From global shares of oil and gas of 33% and 24% in energy consumption in 2015 respectively, the IEA estimates the respective shares of oil and gas to converge at 25% each by 2035. In India, the shares of oil and gas in energy consumption in 2015 and 2016 were 26% and 6.5%, respectively. It is expected to come down while that of gas would rise. A supportive regime for gas has to be put in place for the same to rise to 8-9% by 2040, which will translate into a large supply in absolute numbers. The production potential of different fuels in India (based on the present extent of knowledge of the hydrocarbons potential) varied significantly and hence NEP proposes specific actions for oil and gas to achieve the stated objectives herein (table 2).

Table-2: Domestic Production Potential of Different Fuels in India.

Fuel Types	2012	2022		2040	
		BAU	Ambitious	BAU	Ambitious
Coal (Mtce)	582	904	1006	1190	1385
Oil (Mtoe)	38	44	46	54	61
Gas (BCM)	48	46	53	95	124

The significance of oil and gas to the Indian economy at present underscores the need for a robust strategy for assuring supply. Previous policy statements did aim at increasing domestic production and reducing import dependence. However, while consumption of each has registered sharp increase, production has increased only moderately. From 2005-06 to 2015-16, oil production increased by 15% while consumption of petroleum products increased by 62% and, gas production remained static, though there was an upswing in gas consumption between 2009-12 due to its supplies from KG D6 after which the production has been constantly declining, whereas the consumption increased by 38%. Consequently, India's import dependence and vulnerability to external price and supply shocks in energy domain has increased. In keeping with the overall Objectives of the NEP, robust policy interventions have to be made which will arrest the trend and enhance domestic production. The above scenario also calls for demand side interventions discussed earlier.

Coal

India is well endowed with coal reserves. Approximately 7% of the world's proven coal reserves are located in this country, which enhances its stature amongst the basket of fuels. Additionally, coal is important to us for other reasons — large thermal power capacity, a large employer and negligible price volatility. The large power requirement and solid fuel demand in process industries brings to fore the need for efficient coal exploitation, investment in related infrastructure, and a forward-looking regime. The large planned new coal based thermal capacity is likely to put pressure on coal resources.

The share of coal in India's commercial primary energy supply was 55% in 2015-16 and is expected to remain high during 2040 about 48 -54%. Imports contributed 25% of the supply in 2015-16, and could remain high unless domestic production grows rapidly. The thrust of the NEP will be on interventions required to optimally exploit our coal resources, while addressing the overall environmental concerns related to coal mining. Sustained levels of high domestic production would greatly advance India's energy security. Coal gasification technology and methanol economy also hold value for India to commercially tap our coal resources. In the instant discussion here, we recommend measures, which directly relate to enhancing coal production use efficiency coupled with its optimum use (high efficiency, low emission).

While the role of coal in India's energy future draws mainly from the long history of coal in India and abroad. The electricity markets of the world including India are being shaken by falling costs and rising efficiency of renewable technologies. Experts agree that once the costs of supporting technologies such as battery storage make the cost of variable renewable power viable, coal based power will phase out. This makes the task of projecting the demand for coal difficult. In FY 2017, the addition of conventional power generation capacity in India was surpassed by addition in the renewable sector. The NEP proposes that different fuels are allowed to compete for market and administrative directions to invest or not invest are not given. At present, CIL is making a yearly investment of nearly $1 billion to augment capacity to meet the target of 1 billion tonnes of coal production by 2019. For this investment to be viable, coal-based power capacity must gradually rise to double from the present. It would be desirable that while facilitating the policy and fiscal regimes for coal production in India, we allow decisions to be made on the basis of market cues.

Energy Demand:

The analysis captures the six major energy demand sector: Transport, Buildings, Agriculture, Cooking, Industry, and Telecom.

How the scenarios have been generated:

The IESS, 2047 aims to capture 4 different levels of energy demand for each sector based on the adoption of energy efficiency and technology measures. Two pathways for the demand sectors, based on two different levels of efficiency and technology interventions are constructed and the results are derived from the same. This analysis opts for the Business-As-Usual path and an Ambitious path in order to determine the energy demand for these two scenarios. In the latter path, energy demand falls due to adoption of energy efficiency and behavioural changes. The major factors, among a variety of others, that have been considered on the demand side for this analysis are entailed below:

1. Transport (Passenger and Freight Transport): Transit oriented development is undergoing a shift towards rail based mass transport systems, coupled with the development of the systems, and increasing investments to fuel the same. Further, a shift towards Electric and Hybrid Vehicles, better logistical planning, assisted by information technology solutions to optimize route planning, concentrated economic activity in the form of logistical parks, industrial clusters etc., reducing the demand for Freight Transport. A modal shift towards rail freight, introduction of Dedicated Freight Corridors throughout the four legs of the Golden Quadrilateral, increasing electric traction in Railways etc. are influencing the energy demand.

2. Buildings (Residential and Commercial): In order to manage energy demand a move towards using more energy efficient building materials for the construction (energy efficient building envelopes), strengthening of the Energy Conservation Building Code the Bureau of Energy Efficiency and periodic revisions of the same has been initiated and its adoption is being enhanced better urban planning, adoption of high efficiency lighting technologies and appliances, market transformation to high efficiency appliances, and promotion and adoption of new financial models s being encouraged.

3. Industry: Increasing energy efficiency penetration in the PAT (Perform, Achieve and Trade) scheme to move towards the best available technologies, energy efficiency improvements in the processes of smaller units not under the PAT scheme has been initiated. A move towards more disruptive technologies in the major energy guzzling Iron and Steel (Switch to electric furnace, Increased gas based direct reduced iron, Increased electricity from the grid, and Increased Scrap), and Cement sectors has been undertyaken. Since, the technology employed in ambitious pathway considers a shift from solid and liquid hydrocarbons to electricity, therefore the demand in ambitious pathway has increased as compared to BAU in industry sector.

4. Agriculture: The efficiency of agricultural pump sets has increased by switching over to electric and solar powered pump sets in place of diesel pump sets further a reduction in energy demand from farm mechanization by introduction of fuel efficiency in tractors is also being noticed.

5. Cooking: A shift towards modern fuels for cooking (LPG, PNG), and a improvement in the efficiency of LPG/PNG, Electricity and improved biomass cook stoves has been envisaged. This would lead to an increased demand for gaseous and liquid hydrocarbons and electricity in the ambitious pathway.

6. Telecom: A reduction in the specific fuel requirement of telecom towers by considering a shift away from diesel, in favour of electricity and clean power solutions, and the deployment of green solutions has reduced the energy demand.

Energy Supply:

The IESS offers options to generate the fuel mix on the basis of multiple factors like more domestically produced fossil or non-fossil, cost effective, cheaper, less carbon emitting and higher supplies from emerging technologies. The energy mix selected to meet the chosen level of energy demand works on the principles of a reduction in import dependence and a transition towards cleaner and sustainable supply options. The scenarios have been generated by considering two pathways which were mapped out in the IESS based on a transition towards cleaner sources of energy, and greater indigenous resource production. The scenarios on the supply side assume the meeting of the 175 GW of renewable energy target of the Government of India in 2022 and enhanced deployment thereafter. Two different paths based on the development of a market ecosystem for these technologies have been assumed and alterations in the trajectories of the IESS were done to achieve the same. Since, the ambitious pathway assumes a greater penetration of renewable and cleaner sources of energy and hence the energy supply from the same would be greater in ambitious pathway than BAU. Similarly, the energy supply from coal and oil would be lower in ambitious pathway in comparison with BAU. Suitable options in terms of providing for adequate storage capacities and gas power plants to balance the renewable energy and dialing back of coal power plants when the large amount of renewable energy kicks in has been attempted. Newer source of fuel like Hydrogen for the Telecom and Transport sectors has also been considered. Although the IESS has been used as a platform for constructing this scenario, alterations have been done in order to keep pace with the India's developmental goals and its international commitments.

Outcomes of Improvements in energy supply:

1. Higher domestic fossil fuel production: Mechanisms to augment indigenous resource production, with an aim to reduce import were results in higher domestic coal, oil and gas production. Apart from conventional fuel supplies, unconventional resources such as CBM, UCG and shale oil/gas would also contribute to the domestic production.

2. Thermal Power Generation: Commercialization of newer, and cleaner technologies (e.g: Ultra Supercritical and IGCC in coal based generation etc.) would lead to their increased penetration. Enhanced gas based power generation capacity will encourage cleaner sources of power generation along with balancing requirement for renewable energy capacities. The potential for CCS in coal and gas based generation capacities in the medium to long term are also encouraged.

3. Renewable Energy: Apart from attainment of 175 GW of renewable energy capacity by 2022, the creation of its market and facilitating mechanism post the target year 2022 would lead to its increased adoption by autonomous growth. Solar CSP and offshore wind capacities would also contribute to the Renewable Energy generation capacities other than solar PV, Distributed SPV and onshore wind.

4. Hydro and Nuclear Power Generation: There has been dismal addition of around 2 GW of large hydro power generation capacity in the 12th five-year plan. However, this exercise seeks to exploit the hydro-power potential of the country. India's nuclear power generation capacity would further diversify the sources of electricity generation. The commercial operation for Kudankulam unit 2 is expected to commence in mid-2017, whereas new plants – Kakrapar, Kota and Kudankulam units 3 & 4 are also expected to bear fruit. Further, 10 new PWHR reactors of 700 MWe capacity each are also coming up.

5. Storage Capacities: Increased storage capacities would be established to meet intermittencies due to a high supply of electricity from renewable sources.

6. Biofuels: Enhanced use of liquid biofuels (1st and 2nd generation, advanced biofuels) would curb the country's oil imports. The initiatives would be encouraging use of biogas for cooking in the rural areas.

9.3.2. Energy Demand Management

Types of energy demand management:

Energy efficiency: Using less power to perform the same tasks. This involves a permanent reduction of demand by using more efficient load-intensive appliances such as water heaters, refrigerators or washing machines.

Demand response: It refers to any reactive or preventative method to reduce, flatten or shift demand. Historically, demand response programs have focused on peak reduction to defer the high cost of constructing generation capacity. However, demand response programs are now being looked to assist with changing the net load shape as well, load minus solar and wind generation, to help with integration of variable renewable energy. Demand response includes all intentional modifications to consumption patterns of electricity of end user customers that are intended to alter the timing, level of instantaneous demand or the total electricity consumption. Demand response refers to a wide range of actions which can be taken at the customer side of the electricity meter in response to particular conditions within the electricity system (such as peak period network congestion or high prices) including the aforementioned IDSM.

Dynamic demand: The demand reduced by advance or delay appliance operating cycles by a few seconds to increase the diversity factor of the set of loads. The concept is that by monitoring the power factor of the power grid as well as their own control parameters, individual, intermittent loads would switch on or off at optimal moments to balance the overall system load with generation, reducing critical power mismatches. As this switching would only advance or delay the appliance operating cycle by a few seconds, it would be unnoticeable to the end user. In the United States, in 1982, a (now-lapsed) patent for this idea was issued to power systems engineer Fred Schweppe. This type of dynamic demand control is frequently used for air-conditioners. The Smart AC program in California is the best example in this case.

Distributed Energy Resources: On-site electrical generation and storage performed by a variety of small, grid-connected devices referred to as distributed energy resources (DER). Conventional power stations, such as coal-fired, gas and nuclear powered plants, as well as hydroelectric dams and large-scale solar power stations are centralized and often require electric energy to be transmitted over long distances. By contrast, DER systems are decentralized, modular and more flexible technologies that are located close to the load they serve, albeit having capacities of only 10 megawatts (MW) or less. These systems can comprise multiple generation and storage components which are referred to as hybrid power systems. DER systems typically use renewable energy sources, including small hydro, biomass, biogas, solar power, wind power and geothermal power. Such arrangements play an important role for the electric power distribution system. A grid-connected device for electricity storage can also be classified as a DER system and is often called a distributed energy storage system (DESS). By means of an interface, DER systems can be managed and coordinated within a smart grid. Distributed generation and storage enables collection of energy from many sources and may lower environmental impacts while ensuring improved supply of security.

9.4. Improving Efficiency

The “optimally use of energy in every sector is referred as energy efficiency”. An energy-efficient home not only save expenditure but also conserve the natural resources. Ways to enhance Energy Efficiency:

1. Duct work should be sealed using sealant.
2. A leak left unattended can cost you big time on your water bill. Too often we don’t even realize that there is a leak until it’s too late, and often months have passed with increased electric bills. Keep an eye on your electric bill if you notice a large increase in water or electric usage there may be a problem.
3. If you are like many of us your water heater is in your un insulated garage, but you don’t have to insulate your entire garage to insulate your water heater. You can purchase a water heater jacket for a minimal price and install it yourself, not only reducing the energy the unit has to use to heat your water, but it will decrease the time it takes for hot water to reach other areas of your home.
4. Install a programmable thermostat. Whether you go with a basic unit or one of the new fancy thermostats that programs itself based on your actions, a programmable thermostat will not only save you money but will keep your home much more comfortable.
5. Wash your laundry in cold water. Your clothes will be just as clean, but you’ll save a ton of energy that is wasted just to heat the water.
6. Swap out light bulbs. Old incandescent bulbs stealing energy, therefore swap those old bulbs out for new LED and CFL bulbs. These bulbs use as little as 1/10 of the energy while illuminate much better than old bulbs.
7. Replace appliances before they die. In case you are still using old non-Energy Star appliances (10 years old)consider replacing them with more efficient appliances before they die. You’ll not only save energy (and money) in the long-term but you’ll save yourself from the short-term headache of having to rush out and replace a dead unit.

8. Clean and replace filters. Check your air filters and replace them on a regular schedule.
9. Check the humidity: Monitor the humidity of the houses to keep them cool during summers by installing humidistat. These dehumidifier will keep house cool with less energy and is very efficient.
10. Caulk leaky windows – Use rope caulk to caulk those leaky windows to conserve energy. Those little cracks can equate to having a window (or even two) open as wide as they will go.

9.4.1. Energy efficient Technologies:

There are various technologies for improving efficiency which are described below:

9.4.1.1. Solar Technology

There are three primary technologies by which solar energy is harnessed: photovoltaics (PV), which directly convert light to electricity; concentrating solar power (CSP), which uses heat from the sun (thermal energy) to drive utility-scale, electric turbines; and solar heating and cooling (SHC) systems, which collect thermal energy to provide hot water and air heating or conditioning. Photovoltaic (PV) devices generate electricity directly from sunlight via an electronic process that occurs naturally in certain types of material, called semiconductors. Electrons in these materials are freed by solar energy and can be induced to travel through an electrical circuit, powering electrical devices or sending electricity to the grid. These devices can be used to power anything from small electronics such as calculators and road signs up to homes and large commercial businesses. Photons strike and ionize semiconductor material on the solar panel, causing outer electrons to break free of their atomic bonds. Due to the semiconductor structure, the electrons are forced in one direction creating a

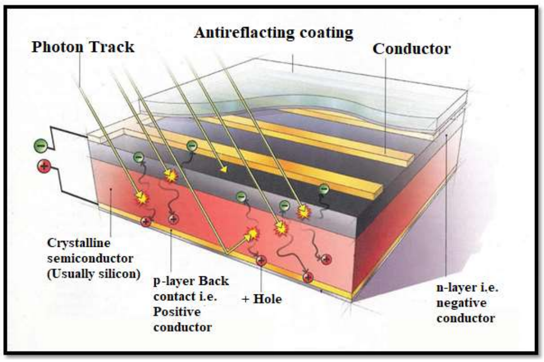


Figure 1. Components of Solar plate

flow of electrical current. Solar cells are not 100% efficient in crystalline silicon solar cells, in part because only certain light within the spectrum can be absorbed, while some of the light spectrum is reflected, one part is too weak to create electricity (infrared), whereas it (ultraviolet fractions) creates heat energy instead of electricity.

In addition to crystalline silicon (c-Si), there are two other main types of PV technology:

Thin-film PV is a fast-growing but small part of the commercial solar market. Many thin-film firms are start-ups developing experimental technologies. They are generally less efficient – but often cheaper – than c-Si modules.

In the United States, **concentrating PV** arrays are found primarily in the desert Southwest. They use lenses and mirrors to reflect concentrated solar energy onto high-efficiency cells. They require direct sunlight and tracking systems to be most effective.

Building integrated photovoltaics serve as both the outer layer of a structure and generate electricity for on-site use or export to the grid. BIPV systems can provide savings in materials and electricity costs, reduce pollution and add to the architectural appeal of a building.

9.4.1.2. Wind Technology

You know that wind is horizontal motion of air. Wind is a form of **solar energy**. Winds are caused by the uneven heating of the atmosphere by the sun and rotation of the earth. Wind flow patterns are modified by the earth's terrain, bodies of water, and vegetative cover. This wind flow, or motion energy, when "harvested" by modern **wind turbines** can be used to generate **electricity**.

The terms "**wind energy**" or "**wind power**" describe the process by which the wind is used to generate **mechanical power or electricity**. Wind turbines convert the kinetic energy in the wind into mechanical power. This mechanical power can be used for specific tasks (such as grinding grain or pumping water) or a generator can convert this mechanical power into electricity to power homes, businesses, schools etc.

Wind turbines, like aircraft propeller blades, turn in the moving air and power an **electric generator** that supplies an electric current. Simply stated, a wind turbine is the opposite of a fan. Instead of using electricity to make wind, like a fan, wind turbines use wind to make electricity. The wind turns the blades, which spin a shaft, which connects to a generator and makes electricity.

Modern wind turbines fall into two basic groups; the **horizontal-axis** variety, like the traditional farm windmills used for pumping water, and the **vertical-axis** design, like the eggbeater-style Darrieus model, named after its French inventor. Now a days are horizontal-axis turbines are used which are modern and large.

Turbine Components

Horizontal turbine components include:

- **Blade** or **rotor**, which converts the energy in the wind to rotational shaft energy;
- A**rive train**, usually including a gearbox and a generator;
- A **tower** that supports the rotor and drive train; and
- Other includs controls, electrical cables, ground support and interconnection equipments.

Wind turbines are available in a variety of sizes and therefore power ratings. The largest machine has blades that span more than the length of a football field, stands 20 building stories high and produces enough electricity to power 1,400 homes. A small home-sized wind machine has rotors between 8 and 25 feet in diameter and stands upwards of 30 feet and can supply the power needs of an all-electric home or small business. **Utility-scale turbines** range in size from 50 to 750 kilowatts. Single small turbines, below 50 kilowatts, are used for homes, telecommunications dishes, or water pumping.

9.4.1.3. Geothermal Technology

Geothermal technology harnesses the earth's heat. Just a few feet below the surface, the earth maintains a near-constant temperature, in contrast to the summer and winter extremes of the ambient air above ground. Farther below the surface, the temperature increases at an average rate of approximately 1°F for every 70 feet in depth. In some regions, tectonic and volcanic activity can bring higher temperatures and pockets of superheated water and steam much closer to the surface.

A ground source heat pump takes advantage of the naturally occurring difference between the above-ground air temperature and the subsurface soil temperature to move heat in support of end uses such as space heating, space cooling (air conditioning) and even water heating. A ground source or geo-exchange system consists of a heat pump connected to a series of buried pipes. One can install the pipes either in horizontal trenches just below the ground surface or in vertical boreholes that go several hundred feet below ground. The heat pump circulates a heat-conveying fluid, sometimes water through the pipes to move heat from point to point.

If the ground temperature is warmer than the ambient air temperature the heat pump can move heat from the ground to the building. The heat pump can also operate in reverse, moving heat from the ambient air in a building into the ground and in turn may result in cooling the building. Ground source heat pumps require a small amount of electricity to drive the heating/cooling process. For every unit of electricity used in operating the system, the heat pump can deliver as much as five times the energy from the ground, resulting in a net energy benefit. Geothermal heat pump users should be aware that in the absence of using renewable generated electricity to drive the heating/cooling process (e.g., modes) that geothermal heat pump systems may not be fully fossil-fuel free (e.g., renewable-based).

The steps below describe how a heat pump works in "heating mode"—taking heat from the ground and delivering it to a building—and "cooling mode," which removes heat from the building and transfers it to the ground.

1. Circulation: The above-ground heat pump moves water or another fluid through a series of buried pipes or ground loops.
2. Heat absorption: As the fluid passes through the ground loop, it absorbs heat from the warmer soil, rock or ground water around it.
3. Heat exchange and use: The heated fluid returns to the building where it can be utilized such as space or water heating. The system uses a heat exchanger to transfer heat into the building's existing air handling, distribution and ventilation system or with the addition of a desuperheater it can also heat domestic water.

4. Recirculation: Once the fluid transfers its heat to the building, it returns at a lower temperature to the ground loop to be heated again. This process is repeated, moving heat from one point to another for the user's benefit and comfort.

The above-ground heat pump is relatively in expensive; with underground installation of ground loops (piping) accounting for most of the system's cost. Heat pumps can support space heating and cooling needs in almost any part of the country and they can also be used for domestic hot water applications. Increasing the capacity of the piping loops can scale this technology for larger buildings or locations where space heating and cooling as well as water heating may be needed for most of the year.

9.4.1.4. Tidal Technology

Tides are the result of the interaction of the gravity of the sun, earth, and moon. The rise and fall of the tides – in some cases by more than 12 m – creates energy. Both forms of energy can be harvested by tidal energy technologies.

Tidal energy is predictable, as the energy production is not influenced by weather conditions but rather by the cycles of the moon, sun and earth, providing a predictable bi-week, biannual and annual cycle. Tidal mills have been used in Europe from around the year 700. Since the 1960s, five projects have been developed commercially.

Tidal range technologies harvest the potential energy created by the difference between low and high tides. The highest tides are usually found in locations where large water masses flow into compounded areas or bays and estuaries.

In those areas, most conventional tidal range schemes use bulb turbines, which are comparable to hydropower turbines that are installed in a dam (run of rivers hydro power plant). Technology developments are comparable to the development of wind turbines. There are a number of other designs that are in the research and development stage. This category includes rotating screw-like devices and tidal kites that carry turbines below their wings.

Tidal range technology has a number of options for power generation:

1. **One way power generation at ebb tide**: A reservoir is filled at flood tide through sluice gates or valves that are closed once the tide has reached its highest level. At the ebb tide, the water in the reservoir is released through the turbines and power is generated. With this single cycle, power is generated for only four hours per day. Annapolis in Canada is an ebb generation plant.
2. **One way power generation at flood tide:** At flood tide the sluice gates are kept closed to isolate the reservoir while at its lowest level. When the tide is high, the water from the sea-side flows into the reservoir via the turbines, thus generating power. The disadvantage of this cycle is that it generates less electricity because of its small capacity. Ecologically it may be disadvantageous as the water level in the impoundment is kept at a low level for a long time. Example,Sihwa, plant generating power through flood tides.
3. **Two way power generation**: Both incoming and outgoing tides generate power through the turbines. This cycle generates power for four hours twice daily. However, reversible turbines are required. La Rance is an ebb and flood generation plant; bulb turbines can also pump water for optimisation.
4. Tidal lagoons are similar to tidal barrage, except that they are not necessarily connected to the shore but could sit within the ocean. Environmental impact assessments of the proposed tidal lagoon in Swansea Bay suggest that lagoons would have lower environmental impacts than tidal barrages.
5. An ultra-low-head tidal technique is a new application under development, which focused on harvesting energy from low head tidal differences of less than 2 (m.
6. The use of tidal fences would consist of a number of individual vertical axis turbines that are connected to each other within a fence structure. The fence itself could be placed between the mainland and a nearby island, or between two islands (as proposed at the San Bernardino Straits in the Philippines). These applications are in their early stages of development and there are no prototypes being tested in the water at present.

7. Hybrid forms of tidal energy can be found in the form of multi-purpose platforms where both tidal current and tidal range technologies are used for electricity generation. These platforms are in an early developmental and innovative stage.

9.4.1.5. Biomass Technology

Biomass has been used as a source of heat energy since man first discovered fire. We have used biomass energy or bioenergy - the energy from organic matter - for thousands of years, ever since people started burning wood to cook food or to keep warm.

And today, wood is still our largest biomass energy resource. But many other sources of biomass can now be used, including plants, residues from agriculture or forestry and the organic component of municipal and industrial wastes. Even the fumes from landfills can be used as a biomass energy source.

The use of biomass energy has the potential to greatly reduce our greenhouse gas emissions. Biomass generates about the same amount of carbon dioxide as fossil fuels, but every time a new plant grows and carbon dioxide is actually removed from the atmosphere. The net emission of carbon dioxide will be zero as long as plants continue to be replenished for biomass energy purposes. These energy crops, such as fast-growing trees and grasses are called biomass feedstocks. The use of biomass feedstocks can also help increase profits for the agricultural industry.

Biomass Energy technology applications:

- Biofuels: Converting biomass into liquid fuels for transportation.
- Biopower: Burning biomass directly, or converting it into a gaseous fuel or oil to generate electricity.
- Bioproducts: Converting biomass into chemicals for making products that typically are made from petroleum.

9.5. Summary

In this unit we have discussed various aspects of energy demand and improving its efficiencies. So far you have learnt that:

- ***Energy conservation is one of the most important aspects at global level. As you know that energy demand increasing day by day and it can leads into to natural resources degradation.***
- ***Energy conservation is the practice of reducing the quantity or amount of energy used. Energy conservation may result in increase of financial growth, better eco-friendly results, national security, personal security etc.***
- ***Energy demand management, also known as demand-side management (DSM) or demand-side response (DSR), is the modification of consumer demand for energy through various methods such as financial incentives and behavioral change through education.***
- ***In relation to its population, India is poorly endowed with energy resources. Its share in the world population is 17% but the shares in the world gas, oil and coal reserves are only 0.6%, 0.4% and 7%, respectively.***
- ***Energy consumption in India is characterized by low per capita level and a large disparity between urban and rural areas. In 2015-16, our per capita energy and electricity consumption at 670 kgoe and at 1075 KWh/year, respectively, are just one third of the world average.***
- ***Amongst fossil fuels, India is most well endowed with coal. Approximately 7% of the world's proven coal reserves are located in India, which enhances its stature amongst the basket of fuels. Additionally, coal is important to us for other reasons — large thermal power capacity, a large employer and negligible price volatility.***
- ***There are various types of energy demand management such as Energy efficiency, Demand response, Dynamic demand, Distributed Energy Resources etc.***
- ***You can improve energy efficiency by different ways such as Seal your duct work, Check your faucets for leaks, Insulate your water heater and pipes, Install a programmable thermostat, Wash your laundry in cold water, Swap***

out light bulbs, Replace appliances before they die, Clean and replace filters etc.

- ***There are various technologies related to improving efficiency which are: Solar Technology, Wind Technology, Geothermal Technology, Tidal Technology and Biomass Technology.***

TERMINAL QUESTIONS

1 (a) Fill in the blank spaces with appropriate words.

In relation to its population, India is poorly endowed with energy resources. Its share in the world population is 17% but the shares in the world gas, oil and coal reserves are only 0.6%, 0.4% and 7%, respectively. This has meant heavy dependence on imports even at a rather low level of energy consumption. It is surprising that despite this severe supply constraint, only recently have we begun to pay serious attention to demand-side interventions that would help economize on the use of energy. There are at least two demand-side interventions that can help cut energy usage: behavioural change that results in reducing the demand for energy-based service and the introduction of alternatives that maintain the level of service but reduce the energy required for its provision. The former is called energy conservation and the latter greater energy efficiency. An example of energy conservation is the shift to fan from air-conditioning, which cuts the need for energy by lowering the level of service received. Similarly, an example of improved energy efficiency is the shift to LED bulbs from regular bulb, which maintains the service but cuts energy consumption. Often conservation and efficiency effects come jointly. For example, when houses are designed to allow better flow of air and the use of air-conditioning is foregone, there is partial decline in service (comfort level) indicating both conservation and efficiency.

2 (a) What is energy conservation? why it is needed?

(b) Discuss the “energy demand”

3. (a) Describe the energy demand at national level.

(b) What are the types of demand management? Explain

4. a) Write about improving efficiency.

5. (a) How you can improve energy efficiency at your home? Explain.

(b) Write about solar technology

(c) Write about the wind technology

6 (a) Fill the blank spaces with appropriate words.

The recently adopted ………….. ……………. ………..(NDCs) as signatory to the ………. …………… …………. ………….. ……….. ………. …………(UNFCCC) emphasize the importance of ………..side factors. In its submission, India gave particular importance to behavioural change leading to………. ……….., something that has received insufficient attention in the developed countries. The ……..aims to internalize this shift in our energy policy. Energy consumption in India is characterized by low per capita level and a large disparity between urban and rural areas. In 2015-16, our per capita energy and electricity consumption at 670 kgoe and at 1075 KWh/year, respectively, are just one third of the world average. Nearly ………….. of our population today is without access to electricity and ….. without access to clean cooking fuel. In 2014, the share of electricity in final energy demand was only 17% compared with 23% in the member countries of ……………. …………….. …………… ………….. ……….. ……………(OECD).

(b) Solar energy is type of (Renewable/Non-renewable)

(c) LED bulb is example of ………..(Eco-friendly technology)

(d) Blade or rotor is used in (wind technology/Solar Technology/ Tidal technology/Biomass technology)

(e) What is tidal energy? How it is produced?

7 (a) Discuss about geothermal technology.

(b) Describe the Biomass technology

ANSWERS

1 (a) Fourth, Wind Power, 32 GW, Tamil Nadu, 7.5 GW, Maharastra, 5GW, Gujarat, 4GWKanyakumari, 380MW

2 (a) see section 9.1 and 9.2.

(b) See section 9.3

3 (a) See section 9.3.1.

(b) See section 9.3.2

4 (a) See section 9.4.

5 (a) See the section 9.4

(b) see the section 9.4.2

(c) See section 9.4.3

6 (a) Nationally Determined Contributions, United Nations Framework Convention on Climate Change, demand, energy conservation, NEP, 25%, 40%, Organization for Economic Cooperation and Development

(b) Renewable energy

(c) Eco-friendly technology

(d) Wind Technology

(e) See the section 9.4.5.

7 (a) See the section 9.4.4

(b) See the section 9.4.6

UNIT-10: ENERGY CONSERVATION I: DEVELOPMENT OF RENEWABLE ENERGY RESOURCES AND RELATED TECHNOLOGIES: BIOENERGY, WASTE FROM MUNICIPAL SECTORS, BIOGAS/METHANE-AGRO AND WOOD; WASTE FOR POWER GENERATION.

Unit Structure

10.0 Learning Objectives

After studying this unit you will be able to understand:

- To provide knowledge on bio-energy, its significance and use
- To provide an insight into bio-energy production technologies.
- To provide understanding and kn0wledge on municipal and agricultural waste and waste to energy.

10.1. Introduction

The energy conservation is practice of reducing the quantity of energy used in the different sectors. It may be achieved through efficient energy use. Energy conservation is one of the easiest way to help the earth by reducing environmental pollution. Energy conservation may leads into financial benefits, national security, human comfort and healthier environment.. Energy conservation plays an important role to create healthier blanket or at lease helps sustain the resources we already have. . As you know that exploitation of non-renewable energy sources (coal, petroleum, fossil fuels etc.) also impacting our environment. Now it is need of hour that we should conserve the energy resources in general and non-renewable energy resources in particular. Energy conservation may be attained by the utilization of alternative sources of energy. These alternative sources of energy may include bio-energy, biogas, methane, wind, solar etc. These alternative energy sources are certainly helpful in national economical development and reducing environmental pollution. Therefore, energy conservation is need of hour. In this unit you will learn about development of renewable energy resources and related technologies: bio-energy, waste from municipal sectors, biogas/methane-agro and wood; waste for power generation.

10.2. Meaning of Renewable energy sources

In previous units of this course you have learnt that **renewable energy sources** are energy sources which can be replenished within the specific amount of time. These **renewable energy sources** are also called **non-conventional energy sources** which are certainly helpful in minimizing environmental pollution and provide alternative option for energy. The common examples of the renewable energy sources are: **solar, wind , tidal, geothermal and biomass energy** etc. Bio-energy fundamentally relies on the biological components such as microbes.

10.3. Bio-energy

A renewable energy resource is derived from biological sources. Biomass is any organic material which has stored sunlight in the form of chemical energy. As a fuel it may include wood, straw, and other agricultural residues, dung cake, manure, and many other by-products from a variety of agricultural processes. In its most narrow sense it is a synonym to **biofuel**, which is fuel derived from biological sources. In its broader sense it includes **biomass**, the biological material used as a biofuel, as well as the social, economic, scientific and technical fields associated with using biological sources for energy.

10.3.1. Importance of Bioenergy

Biomass is a resourceful energy source that can be used for production of heat, power, transport fuels and biomaterials, apart from making a significant contribution to climate change mitigation. Currently, biomass-driven combined heat and power, co-firing, and combustion plants provide reliable, efficient, and clean power and heat. Feedstock for biomass energy plants can include residues from agriculture, forestry, wood processing, and food processing industries, municipal solid wastes, industrial wastes and biomass produced from degraded and marginal lands.

The terms biomass energy, bioenergy and biofuels refer to any energy products derived from plant or animal or organic material. The increasing interest in biomass energy and biofuels has been the result of the following associated benefits:

- Potential to reduce emissions of green house gases emissions.
- Energy security benefits.
- Substitution for diminishing global oil supplies.
- Waste reduction through its conservation energy.
- Technological advancement in thermal and biochemical processes for waste-to-energy transformation.

Biomass can play the pivotal role in production of carbon-neutral fuels of high quality as well as providing feedstocks for various industries. This is a unique property of biomass compared to other renewable energies and which makes biomass a prime alternative to the use of fossil fuels. Performance of biomass-based systems for heat and power generation has been already proved in many situations on commercial as well as domestic scales.

Biomass energy systems have the potential to address many environmental issues, especially greenhouse gases emissions and climate change to foster sustainable development among poor communities. Biomass fuel sources are readily available in rural and urban areas of all countries. Biomass-based industries can provide appreciable employment opportunities and promote biomass re-growth through sustainable land management practices.

The negative aspects of traditional biomass utilization in developing countries can be mitigated by promotion of modern waste-to-energy technologies which provide solid, liquid and gaseous fuels as well as electricity. Biomass wastes can be transformed into clean and efficient energy by biochemical as well as thermo chemical technologies.

The most common technique for producing both heat and electrical energy from biomass wastes is direct combustion. Thermal efficiencies as high as 80 – 90% can be achieved by advanced gasification technology with greatly reduced atmospheric emissions. Combined heat and power (CHP) systems, ranging from small-scale technology to large grid-connected facilities, provide significantly higher efficiencies than the systems that only generate electricity. Biochemical processes, like anaerobic digestion and sanitary landfills can also produce clean energy in the form of biogas and producer gas which can be converted to power and heat using a gas engine.

10.3.2. Production of Bio-energy

Biomass is the organic material derived from plants and animals such as wood from forests, material left over from agricultural and forestry processes, and organic industrial, human and animal wastes. Biomass energy comes from a variety of sources which are given below:

- Wood from natural forests and woodlands
- Forestry plantations
- Forestry residues
- Agricultural residues such as straw, stover, cane trash and green agricultural wastes
- Agro-industrial wastes, such as sugarcane bagasse and rice husk
- Animal wastes
- Industrial wastes, such as black liquor from paper manufacturing
- Sewage
- Municipal solid wastes (MSW)
- Food processing wastes

- When biomass is used as an energy source, it's referred to as **'feedstock'**. Feedstocks can be grown specifically for their energy content (an energy crop), or they can be made up of waste products from industries such as agriculture, food processing or timber production.
- Dry, combustible feedstocks such as wood pellets are burnt in boilers or furnaces. This in turn boils water and creates steam, which drives a turbine to generate electricity.

Wet feedstocks, like food waste for example, are put into sealed tanks where they rot and produce biogas. This gas can be captured and burnt to generate electricity, or it can be injected into the national gas grid and be used for cooking and heating. Bio-energy is a very flexible energy source. It can be turned up and down quickly to meet demand, making it a great backup for weather-dependent renewable technologies such as wind and solar.

10.3.3. Uses of Bio-energy

Biomass can be used to produce renewable electricity, thermal energy, or transportation fuels. It excludes coal, oil, and other fossilized remnants of organisms, as well as soils. In this strict sense, biomass encompasses all living things. Living biomass takes in carbon as it grows and releases this carbon when used for energy, resulting in a carbon-neutral cycle that does not increase the atmospheric concentration of greenhouse gases.

Bioenergy and Agriculture: The carbon dioxide (CO_2) released from biomass during production of bioenergy is from carbon that circulates the atmosphere in a loop through the process of photosynthesis and decomposition. Therefore, production of bioenergy does not contribute extra CO_2 to the atmosphere like fossil fuels. Fossil fuels are a finite resource, developed through geological processes over millions of years and their use represents a one-way flow of GHGs from beneath the earth's surface to the atmosphere.

Reducing greenhouse gas emissions by using bioenergy: The reduction in GHG emissions varies widely and depends on many factors including the biomass used, their production, procurement and the type and efficiency of the technology used to produce bioenergy. Generally, GHG emissions reduction from bioenergy systems is greatest where waste biomass is converted to heat or combined heat and power, in modern plants located near to where the waste is generated.

Bio-energy's GHG reduction benefits are potentially greater than those of other renewables. For example, stubble that is destined to be burnt in the field, can be harvested and combusted in an emissions controlled bio-energy plant. Hence, GHG emissions reductions are made twice – once in the field through reduced burning and again through fossil fuel substitution from bioenergy production.

Bioenergy qualities

Better air quality: Bioenergy can provide air quality benefits where biomass residues that would otherwise be open-burnt in the field or forest, such as stubble, tree prunings or forest slash is removed and burnt in advanced emissions controlled bioenergy plant.

Biofuels are biodegradable: Petroleum-based fuels and petrochemicals can be harmful to the environment and are major surface and ground water-pollutants. Biofuels such as ethanol and biodiesel, are less toxic and biodegradable.

Regional and rural economic development and employment opportunities: International and Australian studies indicate that bioenergy creates many ongoing jobs; generally more than most other types of renewable energy.

Bioenergy helps stimulate regional economic development and employment by providing new, decentralised and diversified income streams from bioenergy and biomass production. This gives landholders more market options for their traditional agriculture, tree crops and use of waste streams such as manures. It may also open opportunities to grow new crops, especially on marginal or low rainfall farmland, e.g. Juncea for biodiesel as a low rainfall break-crop .

Supporting agricultural and food- processing industries: Using biomass can help build resilience in agricultural, timber and food-processing industries. Bioenergy provides a use for their waste streams, can help them reduce their energy costs and potentially add a new revenue stream if they can sell biomass-derived heat and/or export 'green' electricity to the grid.

Cost savings: Using the right bioenergy technology in the right situation can help achieve greater cost savings than using fossil fuels. For example, areas that are reliant on LPG for heating (not linked to natural gas), areas remote from, or near the end of the power grid, subject to 'blackouts' and 'brownouts' and where electricity transmission losses and costs to upgrade the power supply are high.

Less landfill: Using waste streams to generate bioenergy saves the environmental and economic costs of disposal in landfills and reduces contamination risks.

Energy reliability and security: Rural and regional energy reliability and security can be enhanced by providing a domestic energy source that can run continuously, or at peak times as required by the electricity market, with greater flexibility to ramp up production at short notice than large coal-fired plants.

A growing range of technologies and applications: There's a growing range of proven, adaptable technologies available for converting biomass into heat, electricity and biofuels. Bioenergy and biofuel production can link with the development of other bioproducts and biotechnologies. For example, organic digestates produced as a bi- product of anaerobic digestion, can be used as a fertiliser or soil enhancer. Biomass can produce useful chemicals as part of an integrated biorefinery system – similar to an oil refinery.

Alternatives to prescribed forest burning: Bioenergy production can provide an alternative to prescribed burning of forests. Mechanical thinning and biomass removal for bioenergy can be used as a technique to reduce hazardous fuel levels, especially in areas where the cost and risks associated with prescribed burning are high. Water quality benefits have also been recorded where fuel burning is replaced with biomass harvesting. For these reasons, biomass harvesting and removal for bioenergy and other small wood applications is a technique widely used in forests and woodlands in the USA.

Environmental benefits from growing certain bioenergy crops: Bioenergy crops can be grown in areas that benefit from the additional vegetation cover. For example, trees can be grown and harvested for their woody biomass on farms in configurations that provide farm shelter, shade, salinity control, biodiversity and carbon sinks. Species such as *Mallee eucalypts* are widely grown in Australia and, due to their ability to coppice (re-shoot), are able to be repeatedly harvested and regrown to provide renewable energy and other regional as well as on- farm benefits.

10.4. Municipal waste

Municipal waste is that everyday item which is discarded by human being. The composition of municipal solid waste varies greatly from municipality to municipality, and it changes significantly with time. In municipalities which have a well developed waste recycling system, the waste stream mainly consists of intractable wastes such as plastic film and non-recyclable packaging materials. At the start of the 20th century, the majority of domestic waste (53%) in the UK consisted of coal ash from open fires. In developed areas without significant recycling activity it predominantly includes food wastes, market wastes, yard wastes, plastic containers, product packaging materials, and other miscellaneous solid wastes from residential, commercial, institutional, and industrial sources. Most definitions of municipal solid waste do not include industrial wastes, agricultural wastes, medical waste, radioactive waste or sewage sludge. Waste collection is performed by the municipality within a given area. Waste can be classified in several ways but the following list represents a typical classification:

- **Biodegradable waste:** food and kitchen waste, green waste, paper (most can be recycled although some difficult to compost plant material may be excluded).
- **Recyclable materials:** paper, cardboard, glass, bottles, jars, tin cans, aluminum cans, aluminum foil, metals, certain plastics, fabrics, clothes, tires, batteries, etc.
- **Inert waste:** construction and demolition waste, dirt, rocks, debris
- **Electrical and electronic waste (WEEE) : -** electrical appliances, light bulbs, washing machines, TVs, computers, screens, mobile phones, alarm clocks, watches, etc.
- **Composite wastes:** waste clothing, Tetra Packs, waste plastics such as toys
- **Hazardous waste** : It includes most paints, chemicals, tires, batteries, light bulbs, electrical appliances, fluorescent lamps, aerosol spray cans, and fertilizers
- **Toxic waste:** It includes pesticides, herbicides, and fungicides

- **Biomedical waste:** Any kind of material containing infectious material eg. Human anatomical waste, animal waste discarded medicines, waste scraps like needles, syringes, scalpels, bones etc.

10.4.1. Energy Production from Municipal waste

You may know that municipal solid waste can be used to generate energy. Several technologies have been developed that make the processing of MSW for energy generation cleaner and more economical than ever before, including landfill gas capture, combustion, pyrolysis, gasification, and plasma arc *gasification*. While older waste incineration plants emitted a lot of pollutants, recent regulatory changes and new technologies have significantly reduced this concern. United States Environmental Protection Agency (EPA) regulations in 1995 and 2000 under the Clean Air Act have succeeded in reducing emissions of dioxins from waste-to-energy facilities by more than 99 percent below 1990 levels, while mercury emissions have been reduced by over 90 percent. The EPA noted these improvements in 2003, citing waste-to-energy as a power source "with less environmental impact than almost any other source of electricity.

10.4.2. Biogas Production

Biogas is the mixture of gases produced by the breakdown of organic matter in the absence of oxygen. Biogas can be produced from raw materials such as agricultural waste, manure, municipal waste, plant material, sewage, green waste or food waste. Biogas is a renewable energy source.

Biogas is produced by anaerobic digestion with methanogen or anaerobic organisms, which digest material inside a closed system, or fermentation of biodegradable materials. This closed system is called an anaerobic digester, biodigester or a bioreactor. Biogas is primarily methane (CH_4) and carbon dioxide (CO_2) and may have small amounts of hydrogen sulfide (H_2S), moisture and siloxanes. The gases methane, hydrogen, and carbon monoxide (CO) can be combusted or oxidized with oxygen. This energy release allows biogas to be used as a fuel; it can be used for any heating purpose, such as cooking. It can also be used in a gas engine to convert the energy in the gas into electricity and heat.

Biogas can be compressed, the same way as natural gas to CNG, and used to power motor vehicles.

Biogas is produced through the processing of various types of organic waste. It is a renewable and environmentally friendly fuel made from 100% local feedstocks that is suitable for a diversity of uses including road vehicle fuel and industrial uses. The circular-economy impact of biogas production is further enhanced by the organic nutrients recovered in the production process. Biogas can be produced from a vast variety of raw materials (feedstocks). The biggest role in the biogas production process is played by microbes feeding on the biomass. Digestion carried out by these microorganisms produces methane, which can be used as it is locally or upgraded to biogas equivalent to natural gas quality, enabling the transport of the biogas over longer distances. Material containing organic nutrients is also produced in the process, and this can be utilized for purposes such as agriculture.

a) Stages in biogas production

Biogas is produced using well-established technology in a process involving several stages:

1. Bio-waste is crushed into smaller pieces and slurrified to prepare it for the anaerobic digestion process. Slurrifying means adding liquid to the biowaste to make it easier to process.
2. Microbes need warm conditions, so the biowaste is heated to around 37 °C.
3. The actual biogas production takes place through anaerobic digestion in large tanks for about three weeks.
4. In the final stage, the gas is purified (upgraded) by removing impurities and carbon dioxide.

After this, the biogas is ready for use by enterprises and consumers, for example in a liquefied form or following injection into the gas pipeline network.

b) Turning diverse range of materials into gas

Biogas production starts from the arrival of feedstocks at the biogas plant. A diverse range of solid as well as sludge-like feedstocks can be used.

Materials suitable for biogas production include:

- Biodegradable waste from enterprises and industrial facilities, such as surplus lactose from the production of lactose-free dairy products
- Spoiled food from shops
- Biowaste generated by consumers
- Sludge from wastewater treatment plants
- Manure and field biomass from agriculture

The material is typically delivered to the biogas plant's reception pit by lorry or waste management vehicle.

A delivery of solid matter such as bio-waste then undergoes crushing to make its consistency as even as possible. At this point, water containing nutrients obtained from a further stage in the production process is also mixed with the feedstock to take the rate of solid matter down to only around one-tenth of the total volume.

At this stage any unwanted non-biodegradable waste, such as packaging plastic of out-of-date food waste from shops, is separated from the mixture. This waste is taken to a waste treatment facility where it is used to generate heat and electricity. Biomass that has passed through slurrification is combined with biomass delivered in the form of slurry to the biogas plant and pumped into the pre-digester tank where enzymes secreted by bacteria break down the biomass into an even finer consistency.

Next, the biomass is sanitized before entering the actual biogas reactor (digester). In sanitization, any harmful bacteria found in the material are eliminated by heating the mixture to above 70 °C for one hour. Once sanitized, the mass is pumped into the main reactor where biogas production takes place. Sanitization makes it possible to use the fertilizer product in agriculture.

Biomass is turned into gas by microbes: In the biogas reactor, microbial action begins and the biomass enters a gradual process of fermentation. In practice this means that microbes feed on the organic matter, such as proteins, carbohydrates and lipids, and their digestion turns these into methane and carbon dioxide. Most of the organic matter is broken down into biogas, which is a mixture of methane and carbon dioxide – in approximately three weeks. The gas is then collected in a spherical gas holder from the top of the biogas reactors.

Digestate utilized as fertilizers or gardening soil: The residual solids and liquids created in biogas production are referred to as digestate. This digestate goes into a post-digester reactor and from there further into storage tanks and is further used as fertilizers. Digestates can also be centrifuged to separate the solid and liquid parts.

Solid digestates have uses such as fertilizers in agriculture or in landscaping and can also be turned into gardening soil through a process of maturation involving composting. Digestates are centrifuged to yield enough process water for the slurrification of biowaste at the beginning of the process. This helps reduce the use of clean water. The centrifuged liquid is rich in nutrients, particularly nitrogen that can be separated further using methods such as stripping technology and used as fertilizers or nutrient sources in industrial processes.

Clean biogas helps move towards low-carbon society: Gas would already be ready for several uses straight from the biogas plant gas holder. However, before being injected into the gas pipeline network or used to fuel vehicles, it undergoes purification. In this upgrading process, gas is filtered and flown into columns where it is scrubbed by cascading water at a set pressure and temperature. Water efficiently absorbs carbon dioxide and sulfur compounds contained by the gas. Biogas can also be purified using other methods, such as passing it through activated carbon filters to remove impurities. The final upgraded biogas injected into the gas network is at least 95% and usually around 98% methane. Upgraded biogas still contains a couple of per cent of carbon dioxide as its further separation from methane is not cost-effective let alone sensible as regards the usability of the gas. Biogas is dried carefully before injection into the gas network to prevent condensation in winter subzero conditions. The biogas produced can be used for purposes such as fuelling municipal waste management vehicles, urban buses or private cars. At the same time, gas serves as evidence of those practical actions that are taking us towards the low-carbon society of the future.

Table-1: Composition of Biogas: Source: *www.kolumbus.fi, 2007*

Compound	Formula	%

Methane	CH_4	50–75
Carbon dioxide	CO_2	25–50
Nitrogen	N_2	0–10
Hydrogen	H_2	0–1
Hydrogen sulfide	H_2S	0.1 –0.5
Oxygen	O_2	0–0.5

The composition of biogas varies depending upon the substrate composition, as well as the conditions within the anaerobic reactor (temperature and pH). Landfill gas typically has methane concentrations around 50%. Advanced waste treatment technologies can produce biogas with 55%–75% methane, which for reactors with free liquids can be increased to 80%–90% methane using in-situ gas purification techniques. As produced, biogas contains water vapor. The fractional volume of water vapor is a function of biogas temperature; correction of measured gas volume for water vapour content and thermal expansion is easily done via simple mathematics which yields the standardized volume of dry biogas.

In some cases, biogas contains siloxanes. They are formed from the anaerobic decomposition of materials commonly found in soaps and detergents. During combustion of biogas containing siloxanes, silicon is released and can combine with free oxygen or other elements in the combustion gas. Deposits are formed containing mostly silica (SiO_2) or silicates (Si_xO_y) and can contain calcium, sulfur, zinc, phosphorus. Such *white mineral* deposits accumulate to a surface thickness of several millimeters and must be removed by chemical or mechanical means.

Practical and cost-effective technologies to remove siloxanes and other biogas contaminants are available. For 1000 kg (wet weight) of input to a typical biodigester, total solids may be 30% of the wet weight while volatile suspended solids may be 90% of the total solids. In the volatile solids there are 20% proteins, 70% carbohydrates and 10% fats.

Biogas can be used for electricity production on sewage works, in a CHP gas engine, where the waste heat from the engine is conveniently used for heating the digester, cooking, space heating, water heating and process heating. If compressed, it can replace compressed natural gas for use in vehicles, where it can fuel an internal combustion engine or fuel cells and is a much more effective displacer of carbon dioxide than the normal use in on-site CHP plants.

10.4.3. Methane Gas production

Methane was discovered and isolated by Alessandro Volta between 1776 and 1778 when studying marsh gas from Lake Maggiore. It is the major component of natural gas, about 87% by volume. The major source of methane is extraction from geological deposits known as natural gas fields, with coal seam gas extraction becoming a major source. It is associated with other hydrocarbon fuels, and sometimes accompanied by helium and nitrogen. Methane is produced at shallow levels (low pressure) by anaerobic decay of organic matter and reworked methane from deep under the Earth's surface. In general, the sediments that generate natural gas are buried deeper and at higher temperatures than those that contain oil.

Methane is generally transported in bulk by pipeline in its natural gas form, or LNG carriers in its liquefied form; few countries transport it by truck.

Geological routes: The two main routes for geological methane generation are (i) organic (thermally generated, or thermogenic) and (ii) inorganic (abiotic). Thermogenic methane occurs due to the breakup of organic matter at elevated temperatures and pressures in deep sedimentary strata. Most methane in sedimentary basins is thermogenic; therefore, thermogenic methane is the most important source of natural gas. Thermogenic methane components are typically considered to be relic (from an earlier time). Generally, formation of thermogenic methane (at depth) can occur through organic matter breakup, or organic synthesis. Both ways can involve microorganisms (methanogenesis), but may also occur inorganically. The processes involved can also consume methane, with and without microorganisms. The more important source of methane at depth (crystalline bedrock) is abiotic. Abiotic means that methane is created from inorganic compounds, without biological activity, either through magmatic processes or *via* water-rock reactions that occur at low temperatures and pressures, like serpentinization.

Biological routes: Most of Earth's methane is biogenic and is produced by methanogenesis, a form of anaerobic respiration only known to be conducted by some members of the domain, Archaea. Methanogens occupy landfills, other soils, ruminants, the guts of termites, and the anoxic sediments on the seafloor and lakes. Rice fields also generate large amounts of methane during plant growth. A multistep process is used by these microorganisms for energy. The net reaction of methanogenesis is:

$CO_2 + 4\ H_2 \rightarrow CH_4 + 2\ H_2O$

Ruminants: Ruminants, such as cattle, belch methane, accounting for ~22% of the U.S. annual methane emissions to the atmosphere. One study reported that the livestock sector in general (primarily cattle, chickens, and pigs) produces 37% of all human-induced methane. A study done in 2009 found that at a conservative estimate, at least 51% of global greenhouse gas emissions were attributable to the life cycle and supply chain of livestock products, meaning all meat, dairy, and by-products, and their transportation. In 2013, a study estimated that livestock accounted for 44% of human-induced methane and ~15% of human-induced greenhouse gas emissions. Many efforts are underway to reduce livestock methane production, such as medical treatments and dietary adjustments, and to trap the gas to use as energy. The state of California has been particularly active in this area.

Seafloor Sediments: Most of the subseafloor is anoxic because oxygen is removed by aerobic microorganisms within the first few centimeters of the sediment. Below the oxygen replete seafloor, methanogens produce methane that is either used by other organisms or becomes trapped in gas hydrates. These other organisms which utilize methane for energy are known as methanotrophs (methane-eating), and are the main reason why little methane generated at depth reaches the sea surface. Consortia of Archaea and Bacteria have been found to oxidize methane via Anaerobic Oxidation of Methane (AOM); the organisms responsible for this are Anaerobic Methanotrophic Archaea (ANME) and Sulfate-Reducing Bacteria (SRB).

Industrial routes: There is little incentive to produce methane industrially. Methane is produced by hydrogenating carbon dioxide through the Sabatier process. Methane is also a side product of the hydrogenation of carbon monoxide in the Fischer–Tropsch process, which is practiced on a large scale to produce longer-chain molecules than methane. For example of large-scale coal-to-methane gasification in the Great Plains Synfuels plant, which started in 1984 in Beulah, North Dakota as a way to develop abundant local resources of low-grade lignite, a resource that is otherwise difficult to transport for its weight, ash content, low calorific value and propensity to spontaneous combustion during storage and transport. Power to methane is a technology that uses electrical power to produce hydrogen from water by electrolysis and uses the Sabatier reaction to combine hydrogen with carbon dioxide to produce methane. As of 2016, this is mostly under development and not in large-scale use. Theoretically, the process could be used as a buffer for excess and off-peak power generated by highly fluctuating wind generators and solar arrays. However, as currently very large amounts of natural gas are used in power plants (e.g. CCGT) to produce electric energy, the losses in efficiency are not acceptable.

Laboratory synthesis: Methane can be produced by protonation of methyl lithium and methylmagnesium iodide. In practice, a requirement for pure methane will be filled with a steel gas bottle from standard suppliers.

10.4.4. Energy Production By Agro And Wood Materials

Energy production by agro-waste: Large quantities of agricultural wastes, resulting from crop cultivation activities, are a promising source of energy supply for production, processing and domestic activities in rural areas of the concerned region. The available agricultural residues are either being used inefficiently or burnt in the open to clear the fields for subsequent crop cultivation. On an average 1.5 tons of crop residue are generated for processing 1 ton of the main product. In addition, substantial quantities of secondary residues are produced in agro-industries processing farm produce such as paddy, sugarcane, coconut, fruits and vegetables. Agricultural crop residues often have a disposal cost associated with them. Therefore, the “waste-to-energy” conversion processes for heat and power generation, and even in some cases for transport fuel production, can have good economic and market potential. They have value particularly in rural community applications, and are used widely in countries such as Sweden, Denmark, Netherlands, USA, Canada, Austria and Finland.

The energy density and physical properties of agricultural biomass wastes are critical factors for feedstock considerations and need to be understood in order to match a feedstock and processing technology.

There are six generic biomass processing technologies based on direct combustion (for power), anaerobic digestion (for methane-rich biogas), fermentation (of sugars for alcohols), oil exaction (for biodiesel), pyrolysis (for biochar, gas and oils) and gasification (for carbon monoxide and hydrogen-rich syngas). These technologies can then be followed by an array of secondary treatments (stabilization, dewatering, upgrading, refining) depending on specific final products.

It is well-known that power plants based on baled agricultural residues are efficient and cost-effective energy generators. Residues such as rice husks, wheat straw and maize cobs are already concentrated at a point where it is an easily exploitable source of energy, particularly if it can be utilized on-site to provide combined heat and power.

The selection of processing technologies needs to be aligned to the nature and structure of the biomass feedstock and the desired project outputs. It can be seen that direct combustion or gasification of biomass are appropriate when heat and power are required.

Anaerobic digestion, fermentation and oil extraction are suitable when specific biomass wastes are available that have easily extractable oils and sugars or high water contents. On the other hand, only thermal processing of biomass by pyrolysis can provide the platform for all of the above forms of product.

Moisture content is of important interest since it corresponds to one of the main criteria for the selection of energy conversion process technology. Thermal conversion technology requires biomass fuels with low moisture content, while those with high moisture content are more appropriate for biological-based process such as fermentation or anaerobic digestion.

The ash content of biomass influences the expenses related to handling and processing to be included in the overall conversion cost. On the other hand, the chemical composition of ash is a determinant parameter in the consideration of a thermal conversion unit, since it gives rise to problems of slagging, fouling, sintering and corrosion.

Energy production by Wood material:

Wood energy is the energy generated from wood or wood-derived products – usually through combustion processes – and used for cooking, heating or electricity generation. The term “wood energy” is also used to refer to wood and wood-derived materials used for energy purposes (“woodfuel”), which may be in solid, liquid or gaseous form (Figure 1).

Solid woodfuel includes fuelwood (also called firewood), charcoal and wood pellets (briquettes, chips) produced from wood or wood residues. Fuelwood comprises of unprocessed woody biomass harvested from the stems, branches or other parts of trees, and it sometimes is also taken to include wood residues (such as sawdust and wood shavings) derived from timber harvesting or wood-processing industries used for energy production.

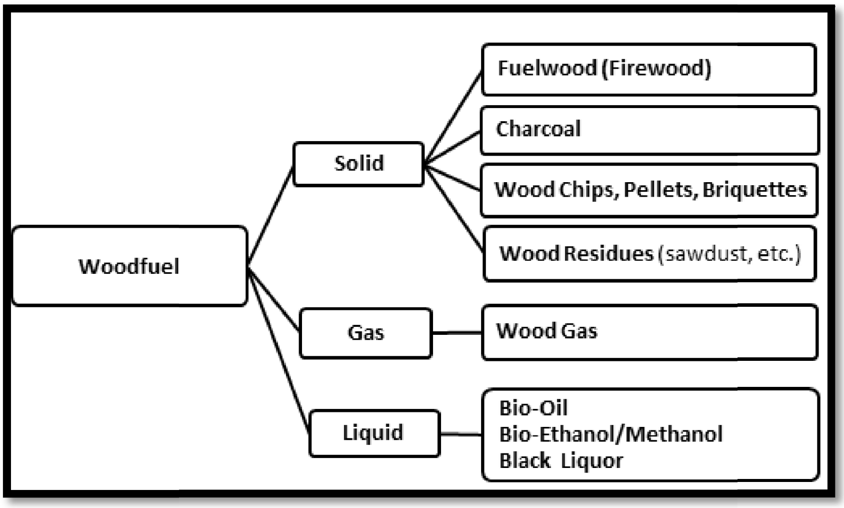


Figure 1: Production of energy from wood material

Gender & wood energy: In many countries, women and girls are primarily responsible for collecting fuel and cooking for their families. In India, for example, women gathering firewood, crop waste and cattle dung fulfill 92 % of rural domestic energy needs. Many of the people who are involved in the woodfuel trade or who work in rural industries or commercial enterprises that use woodfuels are women. Although this means that gender aspects play an important role in wood energy, this is rarely reflected in wood energy planning and programming.

Generally, women are responsible for wood fuel collection by gathering from public sources or from private land, such as farmland and home gardens. Safe access to woodfuel is a direct benefit for their food security and overall health but, depending on the context, collecting woodfuel can be unsafe for the women involved. Efforts have been made to set up tree planting programmes aimed at increasing woodfuel supplies that are easier for women to access and, thus, can reduce gender-based violence. Planting and taking care of the trees means extra work for which women may not have time. When women do plant trees, they are able to use it for household consumption, or sell it for cash, but depending on the cultural and family context, they may not be involved in deciding how to spend that cash. The choice of tree species is also a subject where gender plays a role, because men generally prefer trees that can be sold as timber, while women may prefer fast-growing species that provide them with fuelwood.

Modern use of wood energy

Liquid and gaseous fuels derived from woody biomass are yet to be commercialized for industrial use. On the other hand solid woodfuel in the form of wood pellets and wood chips are used at a large scale for power generation and district heating in many industrialized countries, mainly in Europe. Global wood-pellet production was estimated at around 24 million tonnes in 2014, of which more than 60 percent was produced in Europe and about 26 percent was produced in North America. The United States of America, Germany, Canada and Sweden. The cost breakdown of wood-pellet production and energy consumption along the value chain varies significantly depending on various factors, such as source of wood, harvesting system employed, scale of wood-pellet production and transportation distance. In one case study, the cost breakdown was 40 % feedstock supply, 30 % pellet production and 30 % transportationt. The energy consumed along such a value chain may account for about one-fourth of the total energy content of the wood pellets.

European industrial consumers of wood pellets generally receive certain subsidies because their projects are intended to support compliance with government-sponsored renewable energy and climate-change goals and mandates. The major operators of solid biomass power plants in Europe are the Drax Group (United Kingdom of Great Britain and Northern Ireland), UPM/Pohjolan Volma (Finland), E.ON (Germany), Fortum (Finland) and Vattenfall (Sweden). Wood pellets consumed in the non-industrial sectors in industrialized countries constitute a more-or-less established, affordable heating option that does not necessarily receive government subsidies.

The wood energy sector faces a range of socioeconomic, technological, market, financial, institutional, policy, regulatory and governance barriers that are deeply rooted and which impose significant constraints. A systematic approach – with interventions along the entire value chain – is required to tackle the problems in the sector, which may involve. Recognizing the value and importance of the wood energy sector in the provision of energy services, an assessment of the current status and future trends in wood energy production and consumption, and the development of cross-sectoral enabling policies and measures. A report by the World Bank provides a good example of the importance of awareness-building and sectoral reform. Developing tools to support policy formulation and decision-making processes, particularly in resource assessment, supply–demand analysis, planning and strengthening the institutional framework and cross-sectoral coordination to create an enabling environment for investment and innovation in the wood energy sector. Enhancing technical capacity to improve the sustainability of wood energy production, the effective use of wood waste, the efficiency of charcoal-making, and the cleaner use of wood energy in the household sector. Avoiding or minimizing negative social and environmental impacts associated with scaling up wood energy production to meet demand in industrialized countries. Inviting relevant regional and international organizations to foster dialogue and the exchange of information and experiences on good practices in resource governance for a sustainable wood energy sector

10.5. Summary

In this unit we have discussed various aspects of bioenergy, waste from municipal sectors, biogas/methane-agro and wood; waste for power generation. So far you have learnt that:

- ***The energy conservation is practice of reducing the quantity of energy used in the different sectors. It may be achieved through efficient energy use.***
- ***Bio-energy is type of renewable energy resource which is derived from biological sources. As you know biomass is any organic material which has stored sunlight in the form of chemical energy. As a fuel it may include wood, straw, and other agricultural residues, dung cake, manure, and many other by-products from a variety of agricultural processes.***
- ***Biomass can play the pivotal role in production of carbon-neutral fuels of high quality as well as providing feedstock for various industries. This is a unique property of biomass compared to other renewable energies and which makes biomass a prime alternative to the use of fossil fuels.***

- ***Biomass energy comes from a variety of sources which are wood from natural forests and woodlands, forestry plantations, forestry and agricultural residues such as straw, stover, cane trash and green agricultural wastes, agro-industrial wastes, such as sugarcane bagasse and rice husk, animal wastes, industrial wastes, such as black liquor from paper manufacturing, Sewage, municipal solid wastes (MSW), food processing wastes.***
- ***Biomass can be used to produce renewable electricity, thermal energy, or transportation fuels. It is defined as living or recently dead organisms and any byproducts of those organisms, plant or animal.***
- ***Waste can be classified in several ways such as biodegradable waste, recyclable materials, inert waste, electronic waste, composite wastes, hazardous waste, toxic waste, biomedical waste.***
- ***The composition of Bio-gas comprises of methane, carbon dioxide, nitrogen, hydrogen, hydrogen sulphide and oxygen.***
- ***Methane is generally transported in bulk by pipeline in its natural gas form, or LNG carriers in its liquefied form; few countries transport it by truck. The methane gas production may by the different types Geological routes, Biological routes, Ruminants, Seafloor Sediments, Industrial routes, Laboratory synthesis etc.***
- ***Large quantities of agricultural wastes, resulting from crop cultivation activities, are a promising source of energy supply for production, processing and domestic activities in rural areas of the concerned region.***
- ***The available agricultural residues are either being used inefficiently or burnt in the open to clear the fields for subsequent crop cultivation. On an average 1.5 tons of crop residue are generated for processing 1 ton of the main product.***
- ***In addition, substantial quantities of secondary residues are produced in agro-industries processing farm produce such as paddy, sugarcane, coconut, fruits and vegetables.***

- ***Agricultural crop residues often have a disposal cost associated with them. Therefore, the "waste-to-energy" conversion processes for heat and power generation, and even in some cases for transport fuel production, can have good economic and market potential.***

TERMINAL QUESTIONS

1 (a) Fill in the blank spaces with appropriate words.

Biogas is the mixture of gases produced by the breakdown of …………. ………..in the absence of……… Biogas can be produced from raw materials such as agricultural waste, manure, municipal waste, plant material, sewage, green waste or food waste. Biogas is a ……….energy source.

Biogas is produced by ………digestion with methanogen or anaerobic organisms, which digest material inside a closed system, or fermentation of ……………materials. This closed system is called an anaerobic digester, biodigester or a bioreactor. Biogas is primarily ……….(CH_4) and carbon dioxide (CO_2) and may have small amounts of ………… …………..(H_2S), moisture and siloxanes. The gases methane, hydrogen, and carbon monoxide (CO) can be combusted or oxidized with oxygen. This energy release allows biogas to be used as a fuel; it can be used for any heating purpose, such as cooking. It can also be used in a gas engine to convert the energy in the gas into electricity and heat. Biogas can be compressed, the same way as natural gas is compressed to……., and used to power motor vehicles.

2 (a) What are renewable energy sources? Give the suitable examples.

(b) What do you understand by bioenergy?

3. (a) Write the importance of bioenergy.

(b) Write about production of bio-energy

4. a) Write about uses of bioenergy

5. (a) Write about municipal waste.

(b) How energy is generated from municipal waste? Explain

(c) How biogas is produced? Describe the composition of biogas

6. (a) Fill the blank spaces with appropriate words.

Methane was discovered and ………by ……….. ……….between 1776 and 1778 when studying marsh gas from Lake……… It is the major component of natural gas, about ……. by volume. The major source of methane is extraction from ………..deposits known as natural gas fields, with coal seam gas extraction becoming a major source. It is associated with other hydrocarbon fuels, and sometimes accompanied by ………and nitrogen. Methane is produced at shallow levels (low pressure) by ……….decay of ……….. ……….and reworked methane from deep under the Earth's……... In general, the sediments that generate natural gas are buried deeper and at higher temperatures than those that contain oil.

(b) Which energy is entirely depends on biological components (Solar energy/Hydropower energy/Bio-energy/tidal energy)

(c) Biogas has highest concentration of (Methane/Carbon di oxide/Hydrogen/Nitrogen)

(d) Which of the following can produced energy (Municipal waste/Agro materials/Wood materials /all of these)

(e) Write about methane gas production.

7 (a) How energy is produced by agro and wood materials.

ANSWERS

1 (a) organic matter, oxygen, renewable, anaerobic, biodegradable, methane, hydrogen sulfide, CNG

2 (a) see section 10.2.

(b) See section 10.3 under heading bio-energy

3 (a) See section 10.3.1.

(b) See section 10.3.2

4 (a) See section 10.3.3

5 (a) See the section 10.4

(b) see the section 10.4.1

(c) See section 10.4.2

6 (a) isolated, Alessandro Volta, Maggiore, 87%, geological, helium, anaerobic, organic matter, surface

(b) Bio- energy

(c) Methane

(d) **All of these**

(e) See the section 10.4.3

7 (a) See the section 10.4.4

UNIT-11: Energy Conservation: III

Unit Structure

11.0: Learning Objectives

After studying this unit you will be able to:

- What is energy?
- What are the Renewable energy resources?
- What is Dendrothermal energy?
- What are the types of energy resources?
- What is the significance of renewable energy resources?
- What are energy resources related technologies?
- What do you mean by Ethanol?

11.1 Introduction

The word Energy is derived from the Greek word 'energeia' meaning activity operation, which appears for the first time in the work Nicomachean ethics of Aristotle in the 4^{th} century BC. Like space, time and information, energy is one of the fundamental quantities. Energy is required for all activities. The energy can be use in various ways like to cook food , to provide light, to run the vehicles and to run the machinery in industries. Coal, petroleum, natural gas, Uranium and electricity can generate energy for many purposes.

Mostly earth material is using for fulfillment of human needs and their survival, Various types of metal is required for making machines and other raw material is using to construct the road and buildings. We are using silicon, nickel, and other metals composition to make the computer chips, concrete is also made-up of limestone, gypsum and clay for making the ceramics. Electric circuits are prepared by using gold, silver, copper, aluminum and other metals, jewellary and other ornamental things are the result of corundum (sapphire, ruby, emerald) for abrasives and jewelry.

The renewable energy resources are those natural resources which are inexhaustible (i.e., which can be replaced as we use them) and can be used to produce energy again and again. These are available in unlimited amount in nature and can be develop in a short period of time. These are solar, wind, water, geothermal, ocean, biomass energy, etc.

11.2 Definition of Energy Resources

Energy is the capacity to do work. It is regarded as measure of substance movement. Energy is the measure of a physical system. It defines the quality of the changes and process which take place in the universe, beginning with movement and finishing with thinking. The unity and the connection between the movements forms of substances, their lively capacity of mutual transformation, allowed the measuring of different forms of substance through a common aspect: Energy.

If the energy is in plenty, it can be stored, converted and amplified for our use. Energy resources have been classified into three categories such as fossil fuels, renewable resources and nuclear energy. The fossil fuels contain coal, petroleum and natural gas and on the other hand the renewable resources consider solar, wind, hydroelectricity, biomass and geothermal energy.

Energy plays a key role in development index for a nation. In comparison of old civilization, the modern civilization is much dependent on the availability of energy. So, there is an urgent need to improve the existing technology of energy resources in conventional and non conventional sources of energy.

Fire was the first form of energy technology and the it was commonly used for heating and cooking purposes. Wind and hydropower energy is not a new concept as both are in use for the last 10,000 years. In the modern time, there is a sequential growth of energy as the invention of steam engine replaced the burning of wood by coal and after some time the coal was replaced by oil. This sequence directly has shown the increasing demand of energy.

Energy is the capacity to do work and the word 'Resource' mean Re + Source = again source, the sources which are using again and again known as resources. In other words, the energy resources are the materials which living organisms are taking from the nature for survival.

Energy resources are the opportunities an area offers to generate electricity based on its natural conditions and circumstances. Some of these energy resources are obvious; an area might contain coal, oil, wood, or gas. But others, like renewable resources such as wind, solar, hydroelectric, and wave power are not so obvious— they are based on the natural weather patterns and features of an area.

11.3. Development of renewable resources & related technologies

The concept of energy is not new, the energy is consumed by human civilization from very ancient time. Energy have been an inseparable part for human being and without energy we can not imagine even world on this globe. As human civilization is growing, the demand of energy is increasing day by day. During the past centuries, when human did not know about energy resources around them. They ate raw food material, but with time as human civilization grew, a modern society was made by using various energy resources. They have been depending on energy resources to fulfill their daily need like as cooking, moving from one place to other, keeping houses warm and cold or store food.

Human needed more energy resources to facilitate themselves in various ways. As we heard necessity is the mother of invention, so human developed various technologies to use energy resources. We can see the developmental chain of energy use as human civilization grown on this planet. As human invented the fire firstly and then steam engine and after that the electricity (hydropower, wind power, solar power etc.) energy from the coal (in our houses and in thermal power plants etc) petroleum to run the vehicles etc. Natural gas is the advance version of energy resources to run the vehicles and other machines in industries for better environment. Now days, we are focusing on non conventional sources of energy. So this is the need of hour that technology must be more advance as the energy resources are not able to fulfill the demand of energy for human being.

Energy resources may be divided in to two parts

(i) Conventional source of energy: firewood, cattle dung cake, coal, petroleum, natural gas and electricity (both hydel and thermal).

(ii) Non conventional source of energy: solar, wind, tidal, geothermal, biogas and atomic energy.

Firewood and cattle dung cake are most common in rural India. According to one estimate more than 70 per cent energy requirement in rural households is met by these two; continuation of these is increasingly becoming difficult due to decreasing forest area. Moreover, using dung cake too is being discouraged because it consumes most valuable manure which could be used in agriculture.

11.3.1. Conventional Sources of Energy

11.3.1.1 Coal

As we all know that coal is the conventional source of energy and is being used from various decades. This is the material formed by the compression of plants material over millions of years. Coal is continuously using to cook food, to heat the home during winter.

But due to limited amount of coal, we have limitations to use the coal for various purposes. After coal, we have petroleum which has grown very fast

11.3.1.2 Petroleum

After coal, petroleum is the next important resource and provides energy as fuel in vehicles and used as a raw material in different manufacturing industries and also as a lubricant for machineries. In India, highest amount of petroleum production is from Mumbai 63%, Gujrat contribute 18% and Assam contributes 16% in production of petroleum material. So highest amount of petroleum is being produced from Mumbai, Assam is oldest oil producing state of India.

11.3.1.3 Natural Gas

Natural gas is the clean and modern fuel in comparison of petroleum and coal. It can be use with or without petroleum as a source of energy as well as raw material in a petrochemical industry.

Natural gas contains methane in high amount and this is very efficient fuel and used to minimize air pollution. It is also known as environment friendly fuel as this releases very less amount of CO_2 during the burning process, so this fuel is known as the fuel for present century. There are various reservoirs for natural gas like as a large reserve is situated at Krisna-Godawari basin and Andman Nicobar Island.

11.3.2. Non-Conventional Sources of Energy

Non conventional energy sources can be generated continuously in nature and are in-exhaustive. They can be used again and again in an endless manner.

The growing consumption of energy has resulted in the country becoming increasingly dependent on fossil fuels such as coal, oil and gas. Rising prices of oil and gas and their potential shortages have raise the uncertainties about the security of energy supply in future, which in turn has serious repercussions on the growth of the national economy. Moreover, increasing use of fossil fuels also causes serious environmental problems. Hence, there is a pressing need to use renewable energy sources like solar, wind, tide, biomass and energy from waste material. These are called nonconventional energy sources. India is blessed with abundant of sunlight, water, wind and biomass. It has the largest programs for the development of these renewable energy resources.

Nuclear or Atomic Energy

It is obtained by altering the structure of atoms. When such an alteration is made, much energy is released in the form of heat and this is used to generate electric power. Uranium and Thorium, which are available in Jharkhand and the Aravalli ranges of Rajasthan are used for generating atomic or nuclear power. The Monazite sands of Kerala are also rich in Thorium.

11.3.2.1. Solar energy

India is a tropical country. It has enormous possibilities of trapping solar energy. Photovoltaic technology converts sunlight directly into electricity. Solar energy is fast becoming popular in rural and remote areas. Some big solar power plants are being established in different parts of India which will minimize the dependence of rural households on firewood and dung cakes, which in turn will contribute to environmental conservation and adequate supply of manure in agriculture.

The sun has produced energy for billions of years. Solar energy is the sun's rays (Solar radiation) that reach the earth. It can be converted into other form of energy such as heat and electricity and can be used in following ways.

What is Solar Energy?

Solar energy is energy that comes from the sun. Every day the sun radiates, or sends out, an enormous amount of energy. The sun radiates more energy in one second than people have used since the beginning of time!

It is the energy which comes from the sun; we can trap the solar energy by using some technical devices to use in various ways. India is a tropical country. So, there are enormous possibilities in India to store and use the solar energy. As the photovoltaic cell can convert solar energy directly into electricity and this energy may be useful to run the electronic devices like as calculator, watch etc. India is more dependent on firewood and dung cake, this dependency will minimize by using the new alternatives of energy.

The concept of solar energy is not new as people are using the solar energy for centuries. In 7th century B.C. people have used simple magnifying glasses to focus the light of sun to catch fire to the wood. One century ago, a scientist in France has used the Sun's heat to make steam for a steam engine. A remarkable work has been done by various researchers to improve the solar energy in various ways. In the very beginning of century Charles Greely Abbott (an American astrophysicist) in 1936 has invented a solar boiler for human being.

It takes millions of years for the energy in the sun's core to make its way to the solar surface, and then just a little over eight minutes to travel the 93 million miles to earth. The solar energy travels to the earth at a speed of 186,000 miles per second, the speed of light.

Solar energy can be used as

a. **Photovoltaic cell**
b. **Solar collectors**

i. Passive solar homes

ii. Active solar homes

c. **Solar heating system**
d. **Solar water heating**
e. **Solar space heating of buildings**
f. **Solar air conditioning**

a. Photovoltaic cell

The word "photovoltaic" is the combination of two words first is photo which means the light and second is volt which is a unit of measuring of electricity; photovoltaic cells also known as PV cells or solar cells. Photovoltaic cells performance is directly dependent on the presence of sun light. The presence of cloud and fog or other climatic conditions due to bad weather or other factors have a significant effect on received solar energy by photovoltaic cell and affects its performance. Photovoltaic modules are 10 % efficient in converting sunlight. Fossil fuel plants, on the other hand, convert from 30-40 percent of their fuel's chemical energy into electrical energy. The cost per kilowatt-hour to produce electricity from PV cells is presently three to four times as expensive as from conventional sources. However, PV cells make sense for many uses today, such as providing power in remote areas or other areas where electricity is difficult to provide. Scientists are researching ways to improve PV cell technology to make it more competitive with conventional sources.

Advantages of photovoltaic cell

1. There is no requirement of generator because this cell directly converts the light energy into electricity.
2. There are no restrictions of size and this cell can be installed very quickly.
3. It has very less environmental impact and not requirement of water to cool the device and not generate the byproducts.

b. Solar Collectors

Capturing the solar energy and putting it to work is not an easy task as you see in different devices. Because the sunlight is not stable and we cannot receive the sun light at one place due to the movement in galaxy/cosmos. The receiving of solar energy is dependent on various aspects like as time of the day, longitude, and latitude, altitude of an area, seasons throughout the year and the visibility of the atmosphere. Solar collectors receive the sunlight and absorb it like a car. As in the car the sun rays are penetrating from the glass and absorbed by the seat, wall, mat and various material of the car. The absorbed light can change into heat as in the car the light is penetrating but not get out from the car (as concept of green house, thy work well to get heat inside and don't lets go it outside and stay warm whole year).

The solar collectors play a key role in

1. To allows the sunlight through the glass or plastics.
2. To absorb sunlight and can change into heat.
3. It has the property of trapping the heat energy inside.

c. Solar heating system

Space heating means heating the space inside a building, today many homes use solar energy for space heating. There are two general types of solar space heating systems: passive and active. A "hybrid" system is a mixture of the passive and active systems.

i. Passive Solar Homes

In a **passive** solar home, the whole house operates as a solar collector. A passive house does not use any special mechanical equipment such as pipes, ducts, fans, or pumps to transfer the heat that the house collects on sunny days. Instead, a passive solar home relies on properly oriented windows. Since the sun shines from the south in North America, passive solar homes are built so that most of the windows face south. They have very few or no windows on the north side.

A passive solar home converts solar energy into heat just as a closed car does. Sunlight passes through a home's windows and is absorbed in the walls and floors.

To control the amount of heat in a passive solar house, the doors and windows are closed or opened to keep heated air in or to let it out. At night, special heavy curtains or shades are pulled over the windows to keep the daytime beat inside the house. In the summer, awnings or roof overhangs help to cool the house by shading the windows from the high summer sun.

Heating a house by warming the walls or floors is more comfortable than heating the air inside a house. It is not so drafty. And passive buildings are quiet, peaceful places to live. A passive solar home can get 50 to 80 percent of the heat it needs from the sun. Many homeowners install equipment (such as fans to help circulate air) to get more out of their passive solar homes. When special equipment is added to a passive solar home, the result is called a **hybrid** system.

ii. Active Solar Homes

Unlike a passive solar home, an **active** solar home uses mechanical equipment, such as pumps and blowers, and an outside source of energy to help heat the house when solar energy is not enough. Active systems use special solar collectors that look like boxes covered with glass. Dark-colored metal plates inside the boxes absorb the sunlight and change it into heat. (Black absorbs sunlight more than any other color. Air or a liquid flows through the collectors and is warmed by this heat. The warmed air or liquid is then distributed to the rest of the house just as it would be with an ordinary furnace system. Solar collectors are usually placed high on roofs where they can collect the most sunlight.

They are also put on the south side of the roof where no tall trees or tall buildings will shade them.

d. Solar water heating:

A solar water heater unit comprises a flat plate collector and an insulated storage tank. A typical collector consists of a black metal plate absorber containing metal tubes/pipes for water to remove the heat and is usually provided with a glass cover (one or more layers of glass) and a layer of insulation beneath the plate. The collector tubing/piping is connected to a hot water storage tank. The collector absorbs solar radiations and transfers the heat to the circulating water (either by gravity or by a pump). Usually, the storage tank is located above the top of the collector. The elevated position of the tank results in natural convection, i.e., the water circulates from the collector to the storage tank and no pump is required.

Solar energy is also used to heat water. Water heating is usually the second leading home energy expense, costing the average family over $400, a year. Depending on where you live, and how much hot water your family uses, a solar water heater can pay for itself in as little as five years. A well-maintained system can last 15-20 years, longer than a conventional water heater. This system of water heating is commonly used in hostels, hospitals, hotels, guesthouses etc. as well as in domestic and industrial units. A solar collector area of 3-4 m^2 in combination with an insulated tank of 200-400 liters capacity can provide 200-300 liters of hot water at about 60^0C per average sunny day in a favorable climate.

e. Solar space heating of buildings:

Solar space heating can be provided passively through the architectural design of the premises. At its simplest, this involves only the orientation of the building and providing large south facing windows. More radical possibilities include the provision of an entire wall of double-glazed windows or a heavy dark colored south facing wall behind a layer of glass, with room air circulating by convection between the wall and the glass, or a flat roof covered by a pond of water over which insulating screen can be drawn at night (this also provides cooling in summer).

Alternatively, an active technology of solar space heating where water is the medium, is essentially an extension of the technology employed in solar water heating except that energy has to be recovered from the tank through a heat exchange surface. In system employing air as the heat transfer medium, there is no need of an additional heat exchanger as was the case with water. However water systems are more common than air systems as they offer better heat exchanger performance. Though, they do have the disadvantages of leakage and susceptibility to freezing.

f. Solar Air conditioning

Solar air conditioning includes solar powered refrigeration systems of Rankine cycle systems, absorption refrigerator system and solar regenerated desiccant cooling systems. Out of these, open cycle absorption desiccant cooling systems seemed to offer the best prospects. In a typical desiccant cooling cycle, ambient air is adiabatically cooled, dehumidified and then ducted to the living area. In the regenerative stage, air is evaporatively cooled, heated as it cools the supply air stream, heated again by solar collector and humidified. Simulation and analysis of desiccant cooling system suggest that solar regenerated system can be cost competitive with conventional vapour compression or absorption systems. Desiccant cooling seems best suited for regions with about equal heating and cooling loads and high humidity.

Solar Energy and the Environment

In the 1970s, the push for renewable energy sources was driven by oil shortages and increasing price. Today, this need is also driven by a renewed concern for the environment. Solar energy is the prototype of an environmentally friendly energy source. It consumes none of our precious energy resources, makes no contribution to air, water, or noise pollution, does not pose a health hazard and contributes no harmful waste products to the environment. There are other advantages too. Solar energy cannot be embargoed or controlled by any one nation. And it will not run out until the sun goes out.

Hydro electricity

Electricity has such a wide range of applications in today's world that, its per capita consumption is considered as an index of development. Electricity is generated mainly in two ways: by running water which drives hydro turbines to generate *hydro electricity;* and by burning other fuels such as coal, petroleum and natural gas to drive turbines to produce *thermal power.* Once generated the electricity **is exactly the same.** Hydro electricity is generated by fast flowing water, which is a renewable resource .India has a number of multi-purpose projects like the Bhakra Nangal, Damodar Valley corporation, the Kopili Hydel Project etc. producing hydroelectric power. T*hermal electricity* is generated by using coal, petroleum and natural gas. The thermal power stations use non-renewable fossil fuels for generating electricity. There are over 310 thermal power plants in India.

11.3.2.2. Wind power

India has great potential of wind power. The largest wind farm cluster is located in Tamil Nadu from Nagarcoil to Madurai. Apart from these, Andhra Pradesh, Karnataka, Gujarat, Kerala, Maharashtra and Lakshadweep have many efficient wind farms. Nagarcoil and Jaisalmer are well known for effective use of wind energy in the country.

a. Generation of wind power

The terms "**wind energy**" or "**wind power**" describe the process by which the wind is used to generate **mechanical power or electricity**. Wind turbines convert the kinetic energy in the wind into mechanical power. This mechanical power can be used for specific tasks (such as grinding grain or pumping water) or a generator can convert this mechanical power into electricity to power homes, businesses, schools etc.

b. Wind Turbines

Wind turbines are like aircraft propeller blades which turn in the moving air and power an **electric generator** that supplies an electric current. Simply stated, a wind turbine is the opposite of a fan. Instead of using electricity to make wind, like a fan, wind turbines use wind to make electricity. The wind turns the blades, which spin a shaft, that is connected to a generator and makes electricity.

Wind Turbine Types

Modern wind turbines fall into two basic groups; the **horizontal-axis** variety, like the traditional farm windmills used for pumping water, and the **vertical-axis** design, like the eggbeater-style Darrieus model, named after its French inventor. Most large modern wind turbines are horizontal-axis turbines.

Turbine Components

Horizontal turbine components include:

- **blade** or **rotor**, which converts the energy in the wind to rotational shaft energy;
- a **drive train**, usually including a gearbox and a generator;
- a **tower** that supports the rotor and drive train; and
- other equipment, including controls, electrical cables, ground support equipment, and interconnection equipment.

a. Turbine Configurations

Wind turbines are often grouped together into a single wind power plant, also known as a **wind farm**, and generate bulk electrical power. Electricity from these turbines is fed into a utility grid and distributed to customers, just as with conventional power plants.

b. Wind Turbine Size and Power Ratings

Wind turbines are available in a variety of sizes, and therefore power ratings. The largest machine has blades that span more than the length of a football field, stands 20 building stories high, and produces enough electricity to power 1,400 homes. A small home-sized wind machine has rotors between 8 and 25 feet in diameter and stands upwards of 30 feet and can supply the power needs of an all-electric home or small business. **Utility-scale turbines** range in size from 50 to 750 kilowatts. Single small turbines, below 50 kilowatts, are used for homes, telecommunications dishes, or water pumping.

c. Wind Energy Resources in the United States

Wind energy is very abundant in many parts of the United States. Wind resources are characterized by **wind-power density classes**, ranging from class 1 (the lowest) to class 7 (the highest). Good wind resources for e.g., class 3 and above, which have an average annual wind speed of at least 13 miles per hour are found in many locations. Wind speed is a critical feature of wind resources, because the energy in wind is proportional to the **cube** of the wind speed. In other words, a stronger wind means a lot more power.

d. Advantages and Disadvantages of Wind-Generated Electricity

Wind energy is a **free, renewable resource**, so no matter how much is used today, there will still be the same supply in the future. Wind energy is also a source of **clean, non-polluting, electricity**. Unlike conventional power plants, wind plants emit no air pollutants or greenhouse gases. According to the U.S. Department of Energy, in 1990, California's wind power plants offset the emission of more than 2.5 billion pounds of carbon dioxide and 15 million pounds of other pollutants that would have otherwise been produced. It would take a forest of 90 to 175 million trees to provide the same air quality.

Environmental Concerns

Although wind power plants have relatively little impact on the environment compared to fossil fuel power plants, there is some concern over the **noise** produced by the rotor blades, **aesthetic (visual) impacts**, and birds and bats having been killed (**avian/bat mortality**) by flying into the rotors. Most of these problems have been resolved or greatly reduced through technological development or by properly siting wind plants.

Supply and Transport Issues

The major challenge to use wind as a source of power is that it is **intermittent** and does not always blow when electricity is needed. Wind cannot be stored (although wind-generated electricity can be stored, if batteries are used), and not all winds can be harnessed to meet the electricity demands. Further, good wind sites are often located in **remote locations** far from areas of electric power demand (such as cities). Finally, wind resource development may compete with other uses for the land, and those **alternative uses** may be more highly valued than electricity generation. However, wind turbines can be located on land that is also used for grazing or even farming.

11.3.2.3. Tidal Energy

Oceanic tides can be used to generate electricity. Floodgate dams are built across inlets. During high tide water flows into the inlet and gets trapped when the gate is closed. After the tide falls outside the flood gate, the water retained by the floodgate flows back to the sea via a pipe that carries it through a power-generating turbine. In India the Gulf of Khambhat, the Gulf of Kuchchh in Gujarat on the western coast and Gangetic delta in Sunderban regions of West Bengal provide ideal conditions for utilizing tidal energy.

Tidal power is not a new idea. Mills, which used tidal flow in bays and estuaries to drive machinery to grind cereal, were widely used in medieval times. Tides have been seriously reexamined as a potential source of energy for industry and commerce. In the United

Kingdom, there were numerous proposals throughout the 20th century to exploit the tidal energy potential of the Severn Estuary. None have yet been developed, primarily as a result of the anticipated costs and concern over the environmental changes that would arise from such a large-scale development.

The world's first serious scheme to exploit tidal energy was formed in France, at La Rance in Brittany between 1961 and 1967, and consisted of a barrage across a tidal estuary to utilize the rise and fall in sea level induced by the tides. This scheme has proven to be highly successful despite some early teething problems. Many engineers and developers now favor, however, the use of alternative technology, which will utilize the kinetic energy in flowing tidal currents. Like any energy resource, the prospect of tidal power exploitation has stimulated opposition. Tidal barrage proposals, like La Rance, have produced the most vocal opposition. Environmental groups, although generally in favor of the exploitation of alternative energy sources, are suspicious of the likely environmental changes large estuary based schemes would produce. Political opposition has also been considerable in some cases. One politician in the United Kingdom liked the proposed creation of a barrage across the Severn Estuary for the formation of a "large stinking lake." Similar political opposition has been voiced against any development of the tidal resource in the Solway Firth between Scotland and England. It is anticipated that public and political opposition will limit the development of tidal barrage schemes in the short term.

11.3.2.4. Ocean Energy:

Ocean Thermal Energy Conversion (OTEC) technology is being developed worldwide over the past 15 years. The worldwide OTEC potential is expected to be around 10 million Mw. India has put up the OTEC plant off at one of the islands

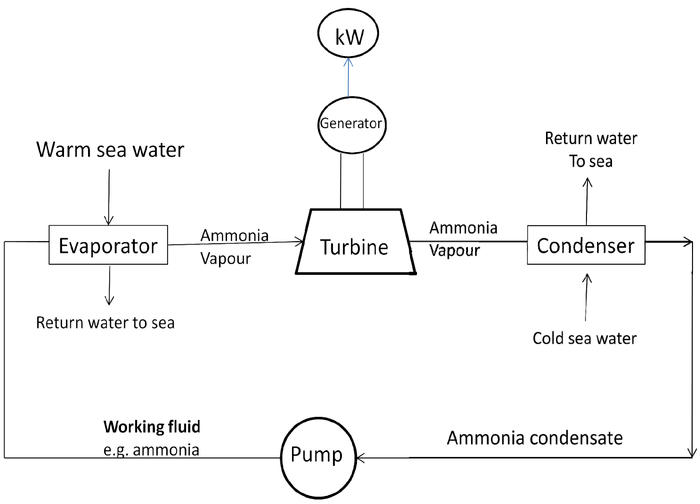


Figure 1. Rankine cycle (closed cycle) OTEC System

of Lakshadweep.

The sun warms the ocean at the surface and wave motion mixes the warm water downward to depths of about 100 m. This mixed layer is separated from the deep cold water, formed at high latitude, by a thermocline. This boundary is sometime marked by an abrupt change in temperature, but more often the changing is gradual. The resulting vertical temperature distribution therefore consists of two layers separated by an interface with temperature difference between them ranging from 10^0 to 30^0C, with the higher values found in the equatorial water. This simple description implies that there are two enormous reservoirs, in some oceanic region, providing the heat source and heat sink required to operate a heat engine. The engine using this energy is referred to as OTEC. The OTEC makes use of the difference in temperature between the two layers of the sea to extract energy. This energy is used to drive turbines for generating electricity.

11.3.2.5. Geo Thermal Energy

Geo thermal energy refers to the heat and electricity produced by using the heat from the interior of the Earth. Geothermal energy exists because, the Earth grows progressively hotter with increasing depth. Where the geothermal gradient is high, high temperatures are found at shallow depths. Groundwater in such area absorbs heat from the rocks and becomes hot. It is so hot that when it rises to the earth's surface, it turns into steam. This steam is used to drive turbines and generate electricity. There are several hundred hot springs in India, which could be used to generate electricity. Two experimental projects have been set up in India to harness geothermal energy. One is located in the Parvati valley near Manikarn in Himachal Pradesh and the other is located in the Puga Valley, Ladakh.

11.3.2.6. Bio-energy

It is the energy produced by using biotic factors. Plants are the main source of energy assimilation. This energy is stored in plants and animals. Plant waste e.g. straw husk, baggase, corn cobs wood shavings, agricultural and forest residues can be harness to utilize bio-energy. Biomass is a renewable form of bio-energy and act as a sink for CO_2. It does not add CO_2 to the atmosphere as it absorbs same amount of carbon in growing as it releases when consumed as fuel.

Way to utilize Biomass

The four ways to utilize Biomass are

(i) Combustion (incineration): It produces heat and electricity and change into a fuel like methane or into a liquid fuel called biofuel.

(ii) Methanisation: It is carried out by anaerobic fermentation of very damp surface such as algae.

(iii) Alcoholic fermentation It is employed with sacchariferous products.

(iv) Thermo chemical transformation It leads to gasification of organic or vegetal substances.

Composition of Biogas

Production of biogas is a anaerobic process with a series of biochemical reactions in which particular kind of bacteria digest biomass. At different stages of digestion process symbiotic group of bacteria perform different function. Hydrolytic bacteria breakdown convert organic waste into sugars and amino acid. Fermentive bacteria convert these products into organic acid, Autogenic microorganism convert the acids into H_2, CO_2 and acetate. Methanogenic bacteria produce biogas from acetic acid, hydrogen and CO_2.

Table:1. Composition of Biogas

Compound	**Percentage (%)**
Methane (CH_4)	50-75
Carbon dioxide (CO_2)	25-50
Nitrogen (N_2)	0-10
Hydrogen (H_2)	0-1
Hydrogen sulphide (H_2S)	0-3
Oxygen (O_2)	0-0

The conversion of biomass to methane is achieved by anaerobic bacterial digestion. The organic matter is decomposed by bacteria in the absence of air or oxygen. Four separate steps are involved in the process.

Step I The insoluble organic substances in the form of polymers are converted into soluble monomers. This is achieved by certain facultative anaerobic microorganisms such as Cellulomonas, Clostridium, Ruminococcus and Eubacterium. They produce enzymes capable of hydrolyzing polymers such as cellulose, hemicellulose, proteins and lipids. The enzymes, therefore are cellulolytic, proteolytic and lipolytic. Lignin of the plant tissues cannot be degraded by these microorganisms. Hence it is left as a residue along with inorganic salts.

Step II The soluble organic material, the monomers are then converted into organic acids by nonmethanogenic bacteria. Acetic and propionic acids are the main products. They are soluble acids.

Step III In the step the dissolved organic acids are converted into methane and carbon dioxide. This is achieved by methanogenic bacteria that are obligatory or strict anaerobes. *Methanobacterium sohengeii*, is a bacillus and *Methanosarcina methanica*, *methanosarcina barkeri* and *methanococcus mazil* are cocci.

Step IV This is the physical process of the transition of the products from the liquid to the gaseous phase.

Among these, the first step or cellulose digestion is the slowest. Therefore, the rate of enzymatic hydrolysis will also determine the rate of gas production. India is a pioneering country in biogas research and development. The khadi and village industries commission took the initiatives for the setting up of gobar gas plants as early as in 1954. At present there is innumerable family as well a few thousand communities that have biogas plants in our country, especially in rural area.

The biogas produced in a digester is a mixture of gases with methane and CO_2 making up more than 90% of the total. It also contain smaller amount of hydrogen sulfide, nitrogen, hydrogen and oxygen. These are the contaminants and source of pollution. If organic waste is rich in N_2 compound, it get converted into oxides of nitrogen on heating and can be extremely harmful. To overcome this problem a new catalyst, mixture of copper oxide and platinum particles suspended in alumina is used. This catalyst works best at 200^0C temperature. It causes modification in the final biogas produced and is far less polluting than before. It could be used as clean source of fuel.

11.4. Energy demand

11.4.1. GLOBAL ENERGY SCENARIO

The International Energy Agency (IEA) forecasts that world primary energy demand between now and 2030 will increase by 1.5% per year from just over 12,000million tonnes of oil equivalent (Mtoe) to 16,800 Mtoe- an overall increase of 40%.Developing Asian countries are the main drivers of this growth, followed by Middle East. Figure 1 provides the global per capita energy consumption statistics.

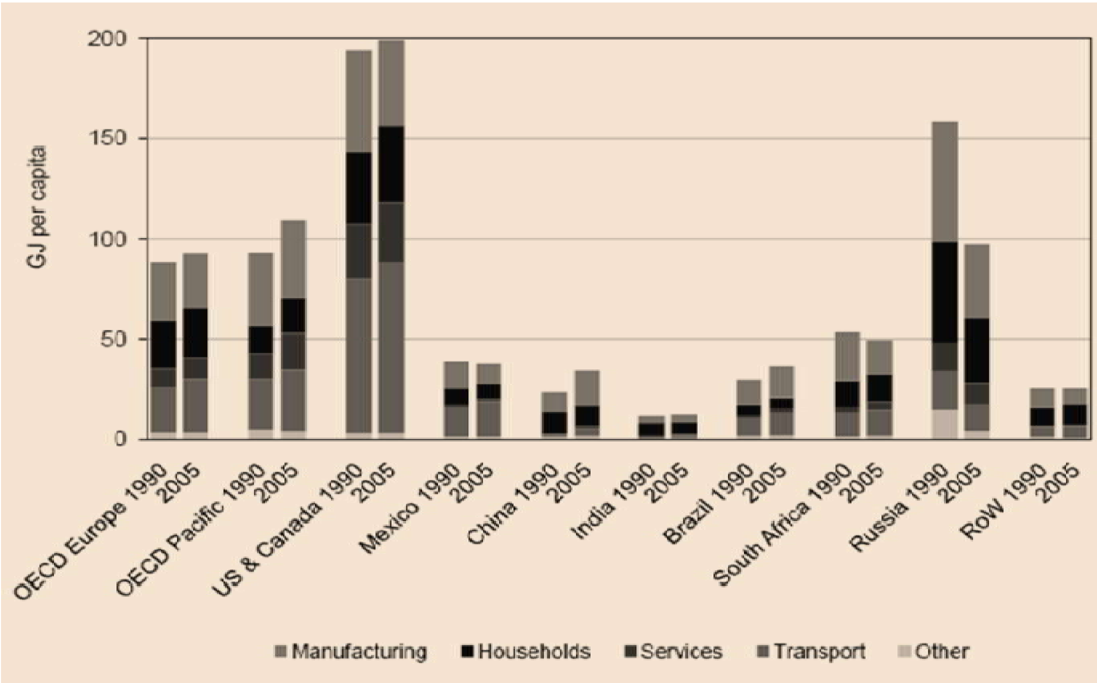


Fig. 2: The growth in per capita energy consumption

As the figure illustrates, the growth in per capita energy consumption over the last two decades world-wide has taken place primarily on account of increased share of the transport sector followed by the manufacturing sector. The exceptions to this trend are China and India where the growth has taken place primarily in the manufacturing sector followed by the household sector. Going forward, some of the trends in global energy consumption are highlighted below:

Fossil fuels, especially coal, are expected to continue to provide the majority of the increase in marketed energy use worldwide. **Oil and other petroleum products are also**

expected to continue to account for the largest share of world energy consumption, but their share is likely to fall over the next couple of years mainly due to increasing world oil prices.

Petroleum and other liquid fuels will remain the most important fuels for **transportation** in the coming years as there are few alternatives that can be expected to compete widely with petroleum-based liquids. **The share of biofuels is also expected to increase in the coming years**. However there is a significant resource issue that will need to be addressed.

The rising price of oil is expected to have an impact on usage and demand for natural gas and non fossil fuel resources as well. Natural gas consumption is likely to go up in 2012 as it will be used to displace the use of liqu.id fuels in the industrial and electric power sectors in many parts of the world.

Global coal consumption is expected to rise sharply with oil and natural gas prices and coal will become appealing for nations with access to sufficient coal resources. This is especially going to be true for China, India, and the United States. Natural gas and coal will continue to provide the massive shares of the total energy used for electricity generation worldwide.

Higher fossil fuel prices, energy security concerns, and environmental considerations are expected to improve the prospects for new nuclear power capacity and other **grid-connected renewable energy sources** in many parts of the world which is expected to continue to expand over 2012. **Rising fossil fuel costs, particularly for natural gas in the electric power sector, along with government policies and programs to support renewable energy, will allow renewable fuels to compete economically over time**.

India's substantial and sustained economic growth is placing enormous demand on its energy resources. The imbalance of demand and supply in energy sources is pervasive requiring serious efforts by government to augment energy supplies. India imports about 80% of its oil. There is a threat of this increasing further, creating serious problems for India's future energy security. There is also a significant risk of lesser thermal capacity being installed on account of lack of indigenous coal in the coming years because of both production and logistic constraints, and increased dependence on imported coal. Significant accretion of gas reserves and production in recent years is likely to mitigate power needs only to a limited extent. Difficulties of large hydropower are increasing and nuclear power is also beset with problems. The country thus faces possible severe energy supply constraints.

Economic growth, increasing prosperity, urbanization, rise in per capita consumption, and spread of energy access are the factors likely to substantially increase the total demand for electricity. Thus there is an emerging energy supply-demand imbalance. Already, in the electricity sector, official peak deficits are of the order of 12.7%, which could increase over the long term.

In view of electricity supply shortages, huge quantities of diesel and furnace oil are being used by all sectors – industrial, commercial, institutional or residential. Lack of rural lighting is leading to large-scale use of kerosene. This usage needs to be reduced, as it is leading to enormous costs in form of subsidies and increasing the country’s import dependence.

At the same time, a very large proportion of the citizens continue to live with no access to electricity and other forms of commercial energy. More than 50% of the population has little or no commercial energy access for their living and livelihood. Others with access often have to cope with poor and erratic availability of electricity and other fuels. With constraints faced in resource availability and in delivery mechanisms, traditional means of energy supply are falling short. This is likely to be the case in the foreseeable future so that energy access will continue to remain a problem.

Role of renewable energy

Renewable energy can make a substantial contribution in each of the above (mentioned areas). it is in this context that the role of renewable energy needs to be seen. It is no longer “alternate energy”, but will increasingly become a key part of the solution to the nation’s energy needs.

Renewable energy has been an important component of India’s energy planning process since quite some time. The importance of renewable energy sources in the transition to a sustainable energy base was recognized in the early 1970s. At the Government level, political commitment to renewable energy manifested itself in the establishment of the first Department of Non-Conventional Energy Sources in 1982, which was then upgraded to a full-fledged Ministry of Non-Conventional Energy Sources (MNES) in 1992 subsequently renamed as Ministry of New and Renewable Energy (MNRE). This is the only such Ministry in the world. MNRE is the nodal Ministry of the Government of India at the Federal level for all matters relating to new and renewable energy. The Ministry has been facilitating the implementation of broad spectrum programs including harnessing renewable power, this energy to rural areas for lighting, cooking and motive power, use of renewable energy in urban, industrial and commercial applications and development of alternate fuels and applications. In addition, it supports research, design and development of new and renewable energy technologies, products and services.

In April 2002, renewable energy based power generation installed capacity was3475 MW which was 2% of the total installed capacity in the country. As on 31.12.2010, it has reached 18,655 MW, which is about 11% of the total installed capacity of 1,68,945MW and corresponds to a contribution of about 4.13% in the electricity mix. Figure 2and Table 1 provides the fuel-wise break-up of the installed power capacity in the country.

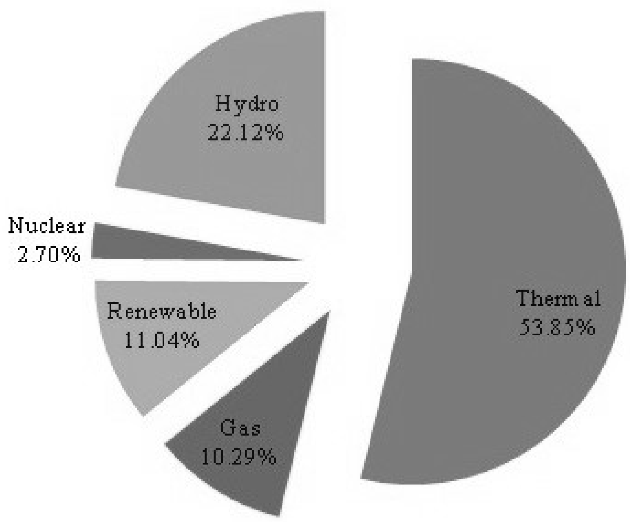


Figure 2: Fuel-wise installed capacity break-up (%)

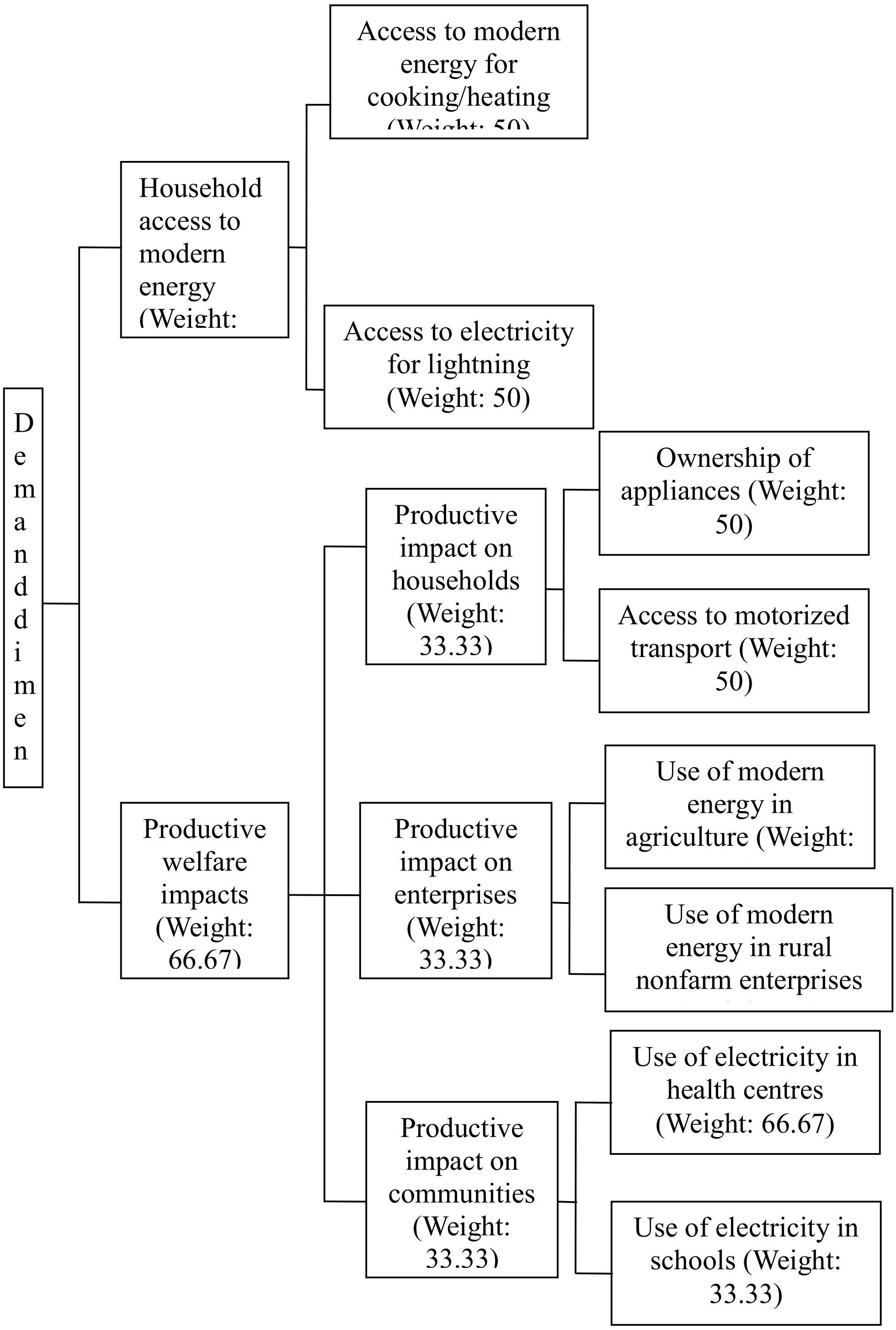


Fig.3: Hierarchy for the demand dimension (Source: Yojana, May 2014)

Development in different sectors relies largely upon energy. Agriculture, industry, mining, transportation, lighting, cooling and heating in buildings, all needs energy. With the demands of growing population the world is facing further energy deficit. The fossil fuels like coal, oil and natural gas which is at present are supplying 95% of the commercial energy of the world resources and are not going to last for many more years. Our life style is changing very fast and from a simple way of life to a more sophisticated one.

11.5. Dendrothermal Energy

Historically, biomass has been a major source of household energy in India. Biomass meets the cooking energy needs of most rural households and half of the urban households (Shukla, 1996). Despite significant increaseof commercial energy in India during last few decades, biomass continues to dominate energy supply in rural and traditional sectors. Estimation of the share of biomass in total energy in India varies from nearly a third (36%) to a half (46%) of total energy (Ravindranath and Hall, 1995). Biomass energy constitutes wood fuels (including charcoal, wood waste wood), crop residues (such as bagasse, rice husk and crop stalks) and animal dung (including biogas). Wood fuels contribute 56 percent of total biomass energy in India (Sinha et. al, 1994). According to the report of the National Council for Applied Economic Research (NCAER, 1985), biomass fuels contributed 90% energy in the rural areas and over 40% in the cities. According to this report, twigs accounted for 75% of household energy needs. The household energy consumption thus appears scarcely a cause of deforestation. Biomass energy is used by over two thirds of Indian households.

Estimates of Biomass Consumption

Estimates of biomass consumption remain highly variable (Ravindranath and Hall, 1995; Joshi et. al., 1992) since most biomass is not transacted on the market. Mean estimates of biomass use (Joshi et. al., 1992) are: fuel wood - 298 million tons, crop residue - 156 million tons and dung cake - 114 million tons. Low to high estimates in this report vary by over sixty percent for fuel wood to five hundred percent for the dung. Supply-side estimates (Ravindranath and Hall, 1995) of biomass energy are reported as: fuel wood for domestic sector- 218.5 million tons (dry), crop residue- 96 million tons (estimate for 1985), and cattle dung cake- 37 million tons. A recent study (Rai and Chakrabarti, 1996) estimated demand in India for fuel wood at 201 million tons (Table 2).

Table 2: Fuel wood demand in India (1996)

Consumption of fuelwood	Million Tons
1. Households	
a. Forested rural	78
b. Non forested rural	74
c. Urban areas	10
Sub total	**162**
2. Cottage industry	**25**
3. Rituals	**04**
4. Hotels etc.	**10**
Total	**201**

Source: Rai & Chakrabarti, 1996

Philippines was among the first nations to initiate the modern biomass programme. A biomass power programme was launched in 1979 with aims to reduce the share of imported oil fired electricity plants to 30% (Durst, 1986a) and to supply electricity to rural areas. Some unique features of the Filipino initiative were - i) large scale, ii) grid based biomass electricity generation, iii) dedicated biomass energy plantations, iv) decentralized and co-operative ownership, v) national co-ordination by the centralized administration, and vi) integration of social and environmental benefits within the program design (Durst, 1987a; Durst 1987b).Biomass supply was planned from the produce of tree farmers on government leased lands. A typical Dendrothermal plant had a 3 MW size, each connected to 1200 hectares plantation (Durst, 1986b). A total of 217 plants (total capacity - 676 MW) were planned for construction in 1980's. Generation cost of electricity was expected to be 4 cents/KWh. The programme expected to save 260,000 barrels of oil per year (Denton, 1981). Tree Farmers Association with 10 to 15 families were formed to manage plantations of 100 hectares size. Within first few years, major efforts were directed towards planting trees and procuring equipments. By1984, equipments were purchased for 17 power plants and 17,827 hectares of land was planted (BTG, 1990). During the time, 338 tree-farmers association with 3,800 member families were registered with the programme (Durst, 1987a).

Since inception, Dendrothermal programme was plagued by serious political, economic and implementation problems. At the time of launching the programme, little experience existed worldwide on wood plantations for energy. Dendrothermal concept needed decentralized management, whereas the planning decisions remained centralized. Lack of institutional mechanisms added to the failures in translating centralized decisions to decentralized implementation and operation. Many tree farmers association had inadequate cultivation experience. As a result, growth and survival rates of trees suffered at many locations. Planning failure is apparent in the decisions of allocating primarily the mountainous sites for plantation and exclusive use of single tree species (*Leucaenal eucocephala* or ipil-ipil) which did not suit the conditions at several sites. While the feasibility studies had projected the annual yields as high as 75 to 100 m^3 per hectare (Bawagan and Semana, 1980), actual yield at some plantations was only a quarter of that projection (BTG, 1990).

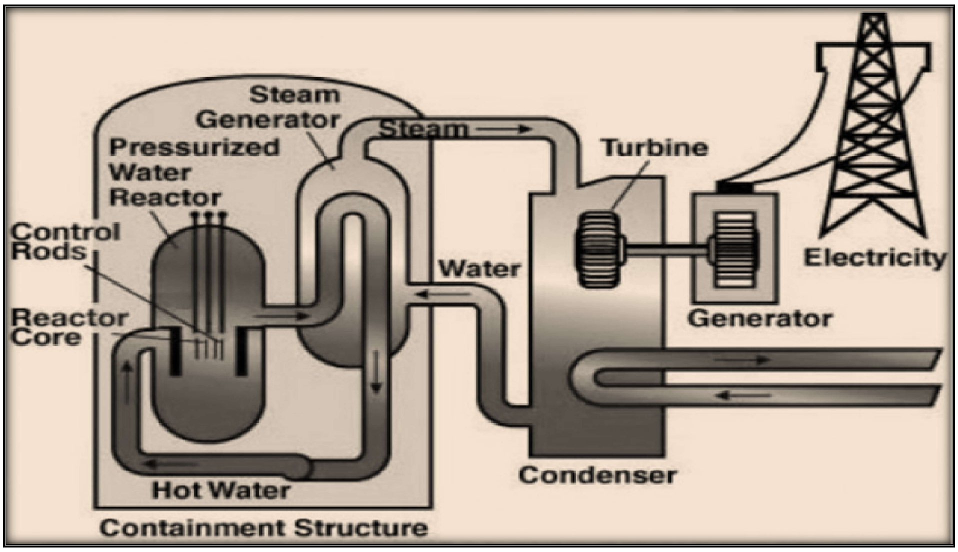


Fig.4: A Dendrothermal Energy plant

An energy that comes from plants is the conversion of wood to electricity. Energy created by burning biomass (fuel wood) to replace the use of fossil fuel for electricity.

Process:

a. Growth of dedicated forest with fast growing tree species, having high energy yield.
b. Regular harvesting of biomass from the forest using coppicing technique. i.e., the tree as a whole is not cut down but pruned systematically.
c. Biomass is transported and fed into the furnace of the conventional steam turbine / generator or fed into a gasifier to produce a combustible gas that could be burnt in a diesel engine couples to an electrical generator.

11.5.1. Environment concerns from traditional Biomass use

The two primary problems with traditional biomass use are the indoor air pollution and the unsustainable resource use. First causes severe health problems for the exposed population. The second adds to the carbon flux in the atmosphere. The traditional energy use in India suffers from both maladies. In efficient biomass technologies, which are perpetuated by the informal and non-market economy, not only cause health problems but contribute to an unsustainable exploitation of resources. The severity of indoor air pollution from biomass combustion in rural Indian households is evident from Table 3. Constant exposure to smoke generated from biomass burning leads to myriad health problems, among women and children who are exposed for long durations indoors. There is strong evidence that biomass use is becoming unsustainable in several parts of India, though the degree may vary from region to region (Agarwal 1986; Dwivedi and Kaul 1997; NWDB1989; Ramana and Joshi, 1997).

The seriousness of the rural energy crisis and associated environment risks was recognized way back in late 1970's. Government then launched a number of dissemination programs for promoting renewable energy technologies to replace traditional biomass technologies and mitigate their environmental ill effects. The largest among the programs were biogas plants (2.57 million individual units installed by October 1997) and improved cook stoves (25 million by October 1997), both in the form of national programs, promoted as efficiency devices for clean cooking. In addition, a number of large-scale area based integrated programmes were also implemented such as community biogas plants, urjagrams (energy villages), and IREP (integrated rural energy planning) programmes.

Table:3 Indoor air pollution from Biofuel combustion

Year	Measurement conditions	No. of Measurements	SPM Concentration (/m^3)
1982	Cooking with wood	22	15800
	Cooking with dung	32	18300
	Cooking with charcoal	10	5500
1988	Cooking, measured 0.7 meters from ceiling	390	4000-21000
Individual			
1983	In 4 villages*	65	6800
1988	In 5 villages*	129	4700
1988	In 2 villages*	44	3600
1988	In 8 villages*	165	3700

***Approx. half of the cooks used cooked stoves fitted with a small chimney. (Source: Smith, 1987)**

Biomass use is growing globally. Advanced biomass energy technologies and the growing awareness and concerns for global climate change and sustainable development are rendering biomass as a viable renewable energy resource. The potential for penetration of biomass energy is evident from the analysis of Renewable-Intensive Global Energy Scenario (RIGES) designed to explore the outlook for renewable energy in the global context (Johansson et al., 1993b). In RIGES, biomass power emerges as a competitive option vis-à-vis coal "under a wide range of circumstances" (Johansson et al., 1993b). Most biomass is used for electricity generation and for fluid fuels and replaces fossil fuels. Biomass electricity can provide 17 percent of power globally in the period 2025 to 2050. Nearly half of biomass electricity generation in developing countries comes from sugar cane bagasse based cogeneration. Plantations based power systems also have a large share. Even under stringent

11.6. Ethanol

Ethanol is a renewable fuel made from various plant materials collectively known as "biomass." More than 98% of U.S. gasoline contains ethanol, typically E10 (10% ethanol, 90% gasoline), to oxygenate the fuel, which reduces air pollution. Ethanol is also available as E85 (high-level ethanol-gasoline blends containing 51% to 83% ethanol, or flex fuel), which can be used in flexible fuel vehicles, designed to operate on any blend of gasoline and ethanol up to 83%. Another blend, E15 (E15 as gasoline blended with 10.5% to 15% ethanol), is approved for use in model year 2001 and newer vehicles.

There are several steps involved in making ethanol available as a vehicle fuel:

- Biomass feedstock are grown, collected and transported to an ethanol production facility.
- Feedstock are converted to ethanol at a production facility and then transported to a fuel terminal or end-user by rail, truck, or barge.
- Ethanol is blended with gasoline at the fuel terminal to make E10 or E85, and then distributed by truck to fueling stations. E15 is generally made at a station by drawing and blending fuel from tanks containing E10 and E85. Some terminals started offering E15 in 2018.

11.6.1. Fuel Properties

Ethanol (C_2H_5OH) is a clear, colorless liquid. It is also known as ethyl alcohol, grain alcohol, and Et OH. Ethanol has the same chemical formula regardless of whether it is produced from starch- and sugar-based feed stocks, such as corn grain (as it primarily is in the United States), sugar cane (as it primarily is in Brazil), or from cellulosic feed stocks (such as wood chips or crop residues).

Ethanol has a higher octane number than gasoline, providing premium blending properties. Minimum octane number requirements for gasoline prevent engine knocking and ensure drivability. Lower-octane gasoline is blended with 10% ethanol to attain the standard 87 octane.

Ethanol contains less energy per gallon than gasoline depending on the volume percentage of ethanol in the blend. Denatured ethanol (98% ethanol) contains about 30% less energy than gasoline per gallon. Ethanol's impact on fuel economy is dependent on its content in the fuel and whether an engine is optimized to run on gasoline or ethanol.

11.6.2. India's ethanol equation

Ethanol blending in petrol is an effective way of increasing domestic petrol availability and for that; all-round efforts need to be made to increase ethanol production

Table:4 Alcohol potential of India

Alcohol requirement (M ltrs)	2011-12	2012-13	2013-14	2014-15
Portable sector	1550	1660	1780	1900
Industrial sector	1100	1160	1210	1280
Blending (5%)	1090	1150	1200	1260
Total alcohol requirement	3740	3970	4190	4440
Highest expected availability	2400	2400	2400	2400
Deficit	1340	1570	1790	2040

Bio-fuels have caught global attention in the last decade. They are renewable liquid fuels made from biological raw materials and have proved to be good substitutes for petroleum in the transportation sector. Being environment friendly, bio-fuels like ethanol and bio-diesel can help us to conform to stricter emission norms. Globally, several policies have given a fillip to bio-fuel production, leading to an increase in ethanol and bio-diesel output.

In order to promote bio-fuels in India, a National Policy on Bio-fuels was formulated by the Union Ministry of New and Renewable Energy in 2009. In January 2013, the Union government launched the Ethanol Blended Petrol (EBP) programme, which made it mandatory for oil companies to sell petrol blended with at least 5 per cent of ethanol. The government initiated significant investments in improving storage and blending infrastructure. The National Policy on Bio-fuels had set a target of 20 per cent blending of bio-fuel by 2017. But the ethanol story has not yet succeeded in India. Let us examine why.

11.6.3 Shortfall in Ethanol supplies

The Ethanol Biofuel Program was initially launched by oil firms in 2003, with an objective of blending ethanol with petrol. Currently, the programme is being implemented in 21 states and 4 union territories with a target of achieving 5 per cent blending and progressively increasing to 10 per cent blending.

According to the Union Ministry of Petroleum and Natural Gas, the approximate ethanol availability in India is 300 crore litres. Of this, about 130 crore litres goes into making liquor, which is non-negotiable for states as liquor is a major revenue source for them. That leaves around 170 crore litres, out of which about 60 to 80 crore litres goes into making chemicals. That leaves about 100 to 120 crore litres for blending. From December 1, 2015 to November 30, 2016, 111 crore litres of ethanol was procured by the Oil Marketing Companies, which was sufficient for blending of only 3.5 per cent. During 2016-17, because of drought in Karnataka and Maharashtra, overall sugarcane and ethanol production reduced considerably and only 66.5 crore litres could be procured from suppliers. According to the Indian Sugar Mills Association (ISMA), sugar mills were set to more than double the supply of ethanol to fuel retailers for blending with gasoline in 2017-18. Ethanol manufactures and OMCs finalised supply contracts for a record 1.4 billion litres during 2017-18 (to realise 4 per cent blending), compared with 665 million litres a year ago.

11.6.4 Fluctuations in supply of raw material

In India, sugarcane molasses are the major resource for bio-ethanol production and inconsistency of raw material supply is the major cause behind the sluggish response to blending targets. Since sugarcane production is cyclical, ethanol production also varies accordingly and does not assure optimum supply levels needed to meet the demand at any given time. The blending targets are partially successful in the years of surplus sugar production but unfulfilled when it declines. Drastic fluctuation in the pricing of sugar cane farming and sugar milling has resulted in mill owners being hugely indebted to farmers. Currently, Uttar Pradesh’s sugar mills have unpaid cane arrears owing to falling prices and a market glut and are saddled with huge quantities of molasses. It is reported that currently, UP sugar mills have unsold molasses of more than 2.62 million tonnes (MT) which have not been procured by liquor manufacturers. Permission is required for transferring molasses intending to produce ethanol and such applications are pending with the state excise department, which need to be processed urgently. As the domestic sourcing of ethanol is continuously failing to achieve the target, there is a need to look at other alternatives.

The National Bio-fuels Policy, 2018, seeks to widen the range of feedstock for ethanol production from the present sugar-molasses to other waste such as rural-urban garbage and cellulosic and lingo-cellulosic biomass, in line with the "waste-to-wealth" concept. The permissible feedstock includes sorghum, sugar-beet, cassava, decaying potatoes, and damaged grain including maize, wheat, rice, and most importantly, crop residue such as wheat and rice stubble. This allows farmers to sell their surplus output to ethanol manufacturers when prices slump.

11.6.5 Second Generation Ethanol Production

The Union government has allowed procurement of ethanol produced from non-food feedstock besides molasses like cellulosic and lingo-cellulosic materials including from the petrochemicals route. In view of the consistent under-supply of domestic ethanol from traditional sources, Second Generation (2G) Ethanol bio-refineries are present across 11 states of the country namely, Punjab, Haryana, Uttar Pradesh, Gujarat, Madhya Pradesh, Maharashtra, Karnataka, Odisha, Bihar, Assam and Andhra Pradesh. Media reports say that oil PSUs have entered into MoUs with state governments and technology providers for 2G ethanol bio-refineries. In fact, the foundation stone for one bio-refinery in Bathinda, Punjab has already been laid. The approximate expenditure for raising each bio-refinery is around Rs. 800-1000 crore and it is expected that an amount of Rs. 10,000 crore will be spent by oil PSUs in setting up these 12 bio-refineries.

Second generation ethanol is based on bio-mass such as wheat straw, rice straw and crop stubble that can be converted into ethanol. It is more expensive than first-generation ethanol. However, by producing 2G ethanol, India can also address a major environmental issue like crop residue burning which is causing horrific pollution in cities like Delhi.

Global outlook of Biofuel

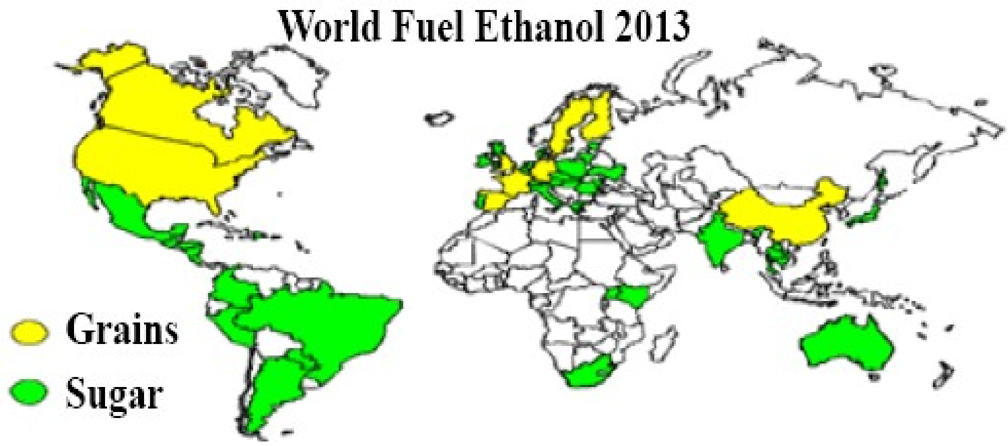


Fig.5: World fuel ethanol scenario (Source: Ministry of economy and industry, Japan)

According to the FAO Agriculture Outlook 2018-27, the demand for bio-fuels is shifting towards developing countries, which are increasingly putting in place policies that favour a domestic bio-fuels market. While declining demand for transport fuel could lead to reduced demand for ethanol in the United States and the European Union —main markets for ethanol—strong growth is expected in Brazil, China, and Thailand, stimulated by favorable policies. In China, demand for ethanol could increase further with the implementation of its proposed new ethanol mandate. According to projections, 84 per cent of the total additional demand for ethanol in the next 10 years will come from developing countries. In many countries, mandatory blending rules impose a minimum share of ethanol and bio-diesel to be used in transport fuel. India, for example, has a target of blending 10 per cent ethanol with petrol by 2022 to cut dependence on imports. To achieve the target, 313 crore litres of ethanol is required. In a slew of decisions, the government has started encouraging sugar mills to divert from sugar and boost ethanol production.

Conclusion

Ethanol blending in petrol is an effective way of increasing domestic petrol availability and for that, all -round efforts need to be made to increase the production of ethanol. The technology for cellulosic and ligno-cellulosic bio-mass is still in the evolving stage which needs to be upgraded and refined for commercial operation. There is also the danger of undue exploitation of the liberalized policy by existing sugar-based ethanol units. In the current scenario, the industry may prefer to convert cane juice directly into ethanol without making sugar. Such a move would become an ecological disaster as sugarcane is a cost-intensive crop that consumes a lot of water which the country can not to grow merely for bio-fuel production. This move needs to be discouraged and closely monitored. Unless the supply of ethanol can be increased from sources other than sugarcane, its use will not be widespread. Recently, the government also proposed blending methanol in petrol as another alternative, but again supply is a problem.

Conservation of Energy Resources

Energy is a basic requirement for economic development. Every sector of the national economy – agriculture, industry, transport, commercial and domestic – needs inputs of energy. The economic development plans implemented since independence necessarily requires increasing amounts of energy to remain operational. As a result, consumption of energy in all forms has been steadily rising all over the country. In this background, there is an urgent need to develop a sustainable path of energy development. Promotion of energy conservation and increased use of renewable energy sources are the twin planks of sustainable energy. India is presently one of the least energy efficient countries in the world. We have to adopt a cautious approach for the judicious use of our limited energy resources. For example, as concerned citizens we can do our

bit by using public transport systems instead of individual vehicles; switching off electricity when not in use, using power-saving devices and using non-conventional sources of energy. After all, "energy saved is energy produced".

11.7 Summary

In this unit we have examined various aspects of energy resources so far you have learnt that word Energy is derived from the Greek word 'energeia' meaning activity operation, which appears for the first time in the work Nicomachean ethics of Aristotle in the 4th century BC. Like space, time and information, energy is one of the fundamental quantities. Energy is required for all activities. The energy can be use in various ways like to cook food , to provide light, to run the vehicles and to run the

machinery in industries. Coal, petroleum, natural gas, Uranium and electricity can generate energy for many purposes.

According to the FAO Agriculture Outlook 2018-27, the demand for bio-fuels is shifting towards developing countries, which are increasingly putting in place policies that favour a domestic bio-fuels market. While declining demand for transport fuel could lead to reduced demand for ethanol in the United States and the European Union —main markets for ethanol—strong growth is expected in Brazil, China, and Thailand, stimulated by favorable policies. In China, demand for ethanol could increase further with the implementation of its proposed new ethanol mandate. According to projections, 84 per cent of the total additional demand for ethanol in the next 10 years will come from developing countries. In many countries, mandatory blending rules impose a minimum share of ethanol and bio-diesel to be used in transport fuel. India, for example, has a target of blending 10 per cent ethanol with petrol by 2022 to cut dependence on imports. To achieve the target, 313 crore litres of ethanol is required. In a slew of decisions, the government has started encouraging sugar mills to divert from sugar and boost ethanol production.

Terminal question

1. (a) Fill in the blank spaces with appropriate words.

Ethanol is a renewable fuel made from various plant materials collectively known as "…………………." More than …………% of U.S. gasoline contains ethanol, typically E10 (…………….% ethanol, 90% gasoline), to oxygenate the fuel, which reduces……………………. Ethanol is also available as …………………..(high-level ethanol-gasoline blends containing 51% to 83% ethanol, or flex fuel), which can be used in flexible……………………., designed to operate on any blend of gasoline and ethanol up to 83%. Another blend, E15 (E15 as gasoline blended with 10.5% to 15% ethanol), is approved for use in model year ………………….. and newer vehicles.

2. (a) Discuss the types of energy resources.

(b) How conventional resources are eco friendly?

3. (a) Describe the wind energy.

(b) Discuss the Solar energy.

4. a) What do you meant by the conventional source of energy? Explain the Ethanol in detail?

5. (a) Explain the Dendrothermal energy.

(b)Discuss the need of biofuel?

(c) Discuss the shortcoming of wind energy.

6. (a) In the United States, 95% of ethanol is produced from the starch in corn grain weight. (Yes/No)

(b) The Ethanol Biofuel Program was initially launched by oil firms in ……. (2003/2008)

(c) Which one of the following is major component of biogas (Methane/Butane/propane)

(d) What do you understand by ocean energy?

6. Describe the non conventional source of energy.

2.11 Answers

1 (a) biomass, 98, 10, air pollution, E85, fuel vehicles, 2001

2 (a) See section 11.3

(b) See section 11.3.2

3 (a) See section 11.3.2.2

(b) See section 11.3.2.1

4 (a) See section 11.5

5 (a)See section 11.4

(b) See section 11.3.2.6.

(c) See section 11.3.2.2

6 (a) Yes

(b) 2003

(c) Methane

(d) See section 11.3.2.4

UNIT-12: Energy Conservation & Biofuel Farming

Unit Structure

12.0. Learning Objectives

After studying this unit you will be able to:

- What is energy?
- What is energy conservation?
- What are the biofuels?
- What are the types of energy resources?
- What is the significance of biofuel farming?
- What are the effects of biofuel farming on environment?
- What do you mean by Ethanol?

12.1. Introduction

Sustainable development is one of the driving force toward the quest of renewable energy. This has been furthered by the depletion of fossil fuels and the destruction of the ozone layer due to greenhouse gases. Thus, sustainability can be achieved by diversifying energy sources, with a strong focus on renewable energy. In this case, it means revitalisation of agriculture is a necessity if such a goal is to be achieved. Biofuels is one of the means in achieving these goals. They are defined as liquid fuels that are derived from materials such as plant waste and animal matter. Two classes of biofuels exists, these are namely; first generation and second generation. According to Naik *et al..,* (2010) first generation biofuels include biodiesel, bio ethanol and biogas, and are resourced mainly from edible food material such as maize, soybean, oil palm, sugar cane and cassava. Second generation biofuels are sourced from nonedible sources such as jatropha and algae. In developing countries, biofuels have become central in debates due to their potential to improve social development. Growing evidence has also revealed that biofuels can have a positive impact in improving energy security and reducing greenhouse gases. However, to date our knowledge on using energy policy to contribute to its growth is very limited (Costa-Campi *et al.*., 2015). Yoon and Sim (2015) and Morrison *et al.* (2016)

claimed that the biofuels industry has struggled to be viable despite immense technological developments. As pointed by Boucher *et al.* (2014), biofuel policy is developed with limited participation from industry and stakeholder.

South Africa has been facing a number of challenges in energy security with the country now contemplating building nuclear reactors to improve this situation. Recently efforts have shifted to biofuels production as an alternative because of its potential to improve energy security, reduce climate change and reduce emissions. Moreover, biofuels presents an opportunity to increase rural employment (Takavarasha *et al*.., 2005). In line with the potential threats faced in energy, the South African government launched the Biofuel Industrial Strategy Policy (BIS) in 2007. The policy was launched in order to address some challenges such as, smallholder productivity, upliftment of agriculture using surplus land, promoting sustainable development and improving energy security (DME, 2007).

12.1.1 Biofuel history

Biofuel is the modern concept in comparison of other renewable energy resources such as solar energy, wind, hydropower etc.But, the concept of bio-fuel or bio-diesel was used in later part of the previous century. Here we consider the biomass, as the source of renewable energy, which is converted to methanol or ethanol etc. and mixed partially with diesel (up to 5%) to use in diesel engines (in automobiles, industries etc.). In future, the bio-fuel may be used neatly without using of any type of fossil fuel like as Diesel (B100) or petrol.

In ancient time, as Mr. Rudolf Diesel in 1890 evolved diesel engine. He has suggested vegetable oil in diesel engines to the remote areas, where diesel is not found or available.

During late 1800's ethanol (derived from the corn) was used in power cars particularly for Hanry Ford's model-T. The Pacific Biodiesel became one of the first biodiesel plants in the United States in 1996, establishing a biodiesel production operation to recycle used cooking oil into biodiesel on the island Maui in Hawaii. The biodiesel production got boosting after the 2001 due to skyrocketing price of the petroleum byproducts. Biodeisel has become a fastest growing fuel in the world due to its eco-friendly characteristics, very easy to use and other benefits.

12.2. Definition of Energy conservation and Biofuel farming

India is one of the fastest growing economies in the world. The Development Objectives focus on economic growth, equity and human wellbeing. Energy is a critical input for socio-economic development. The energy strategy of a country aims at efficiency and security and to provide access which being environment friendly and achievement of an optimum mix of primary resources for energy generation. Fossil fuels will continue to play a dominant role in the energy scenario of our country in the next few decades. However, conventional or fossil fuel resources are limited, non-renewable, polluting and therefore, need to be used prudently. On the other hand, renewable energy resources are indigenous, non-polluting and virtually inexhaustible. Also, India is endowed with abundant renewable energy resources. Therefore, their use should be encouraged in every possible way.

The crude oil price has been fluctuating in the world market and has increased significantly in the recent past, reaching a level of more than $ 140 per barrel. Such unforeseen escalation of crude oil prices is severely straining various economies the world over, particularly those of the developing countries. Petro-based oil meets about 95% of the requirement for transportation fuels, and the demand has been steadily rising. Provisional estimates have indicated crude oil consumption in 2007-08 at about 156 million tonnes. The domestic crude oil is able to meet only about 23% of the demand, while the rest is 1.3 India's energy security would remain vulnerable until alternative fuels to substitute/supplement petro-based fuels are developed based on indigenously produced renewable feedstock.

"Biofuels" are environment friendly fuels and their utilization would address global concerns about containment of carbon emissions. The transportation sector has been identified as a major polluting sector. Uses of biofuel have, therefore, become compelling in view of the tightening automotive vehicle emission standards to curb air pollution.

“Biofuels” are derived from renewable bio-mass resources and, therefore, provide a strategic advantage to promote sustainable development and to supplement conventional energy sources in meeting the rapidly increasing requirements for transportation fuels associated with high economic growth, as well as in meeting the energy needs of India’s vast rural population.

12.2.1 Definitions And Scope

The following definitions of biofuels shall apply for the purpose of this Policy:

i. ‘biofuels’ are liquid or gaseous fuels produced from biomass resources and used in place of, or in addition to, diesel, petrol or other fossil fuels for transport, stationary, portable and other applications;

ii. ‘biomass’ resources are the biodegradable fraction of products, wastes and residues from agriculture, forestry and related industries as well as the biodegradable fraction of industrial and municipal wastes.

3.2 The scope of the Policy encompasses bio-ethanol, bio-diesel and other biofuels, as listed below:-

i. ‘Bio-ethanol’: ethanol produced from biomass such as sugar containing materials, like sugar cane, sugar beet, sweet sorghum, etc.; starch containing materials such as corn, cassava, algae etc.; and, cellulosic materials such as bagasse, wood waste, agricultural and forestry residues etc.

ii. ‘Biodiesel’: a methyl or ethyl ester of fatty acids produced from vegetable oils, both edible and non-edible, or animal fat of diesel quality; and , The focus for development of biofuels in India will be to utilize waste and degraded forest and non-forest lands only for cultivation of shrubs and trees bearing non-edible oil seeds for production of bio-diesel. In India, bio-ethanol is produced mainly from molasses, a by-product of the sugar industry. In future too, it would be ensured that the next generation of technologies is based on non-food feed stocks. Therefore, the issue of fuel vs. food security is not relevant in the Indian context.

Cultivators, farmers, landless labourers etc. will be encouraged to undertake plantations that provide the feedstock for bio-diesel and bio-ethanol. Corporate will also be enabled to undertake plantations through contract farming by involving farmers, cooperatives and Self Help Groups etc. In view of the current direct and indirect subsidies to fossil fuels and distortions in energy pricing, a level playing field is necessary for accelerated development and utilization of biofuels to sub serve the Policy objectives. Appropriate financial and fiscal measures will be considered from time to time to support the development and promotion of biofuels and their utilization indifferent sectors.

12.2.2 Production techniques

Biofuel production techniques widely vary, depending on the type of raw material, efficiency level, production volume, surrounding situation and end-users requirement etc

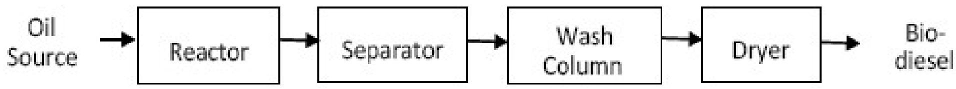


Fig: 1 Stage of biodiesel production

Production of Biofuel is depending on the type of raw material, efficiency level, production volume, surrounding situation and end-users requirement etc. Algae biodiesel Algae are aquatic oxygenic prototroph. Microalgae are considered to be attractive source for energy for various reasons, Such as: The biomass productivities (dry weight per unit time per unit area) of some microalgae are much higher than those of higher plants. Some microalgae grow fast. The lipid and starch contents of some microalgae are high and easy to cultivate. Algae can be cultivated on non arable land or in water. Thus, the energy production by algae does not compete for land with food production. However, the cost of biodiesel production from algae is very high. Cultivating algae under rural conditions requires novel multi-tier, multi-cyclic approaches of sharing land area without causing threats to food and water security as well as demand for additional fertilizer resources by adopting multi-tier cropping (algae-paddy) in decentralized open pond systems.

Cellulose (in paper, cotton, and wood) and starch (in food) is a polymer of glucose, a simple sugar that is easily consumed by yeast to produce ethanol. Cellulose is produced by every living being. The three major challenges in cellulose ethanol production are; Firstly, cellulosic feed stocks must be available in large volumes when needed by refineries. Second, the cost of converting cellulose to ethanol or other biofuels must be reduced to a level to make it competitive with gasoline and corn-starch ethanol. Third, the marketing, distribution, and vehicle infrastructure must absorb the increasing volumes of renewable fuel, including cellulosic fuel mandated by the RFS.

The renewable sources have a major concern of lack of continuous supply of energy to the users, as the resources are discrete in nature. Secondly, in most of the sources are overestimated. For instance, Jatropha is considered as one of the most promising technology, but, later found unsuitable in terms of high investment to seed productivity ratio. It has gradually been discontinued in India. In US, the year's mandate for 2011, was supposed to be 100 million gallons of cellulosic biofuel, but that was reduced to 6.5 million. Thirdly, there is debate on the use of edible oil and feed for biofuel production.

12.2.3 Biofuel resources in India

Biofuel potential Energy consumption is increasing at 6.5 per cent per annum, while reserves of petroleum are decreasing day by day. India's share of crude oil production is about 1 per cent of global crude oil production, whereas consumption amounts to 3.1 per cent of global consumption. A no. of private and Government organizations are involved in production and distribution biofuel in India. The leaders in biofuel processing in India are, D1 Oil Plc, Reliance Industries Ltd, Godrej Agrovet, Emami Group, Aatmiya Biofuels Pvt Ltd., Gujarat Oelo Chem Limited (GOCL), Jain Irrigation System Ltd., Nova Bio Fuels Pvt. Ltd., Sagar Jatropha Oil Extractions Private Limited etc. It is wise to consider the oil yield potential of different edible and non-edible crops, before selecting the crop as suitable source of biodiesel production. Considering the food grain scarcity in developing countries like India, edible major crops may be spared as a potential source for bio-diesel production. Typical feed stocks for biodiesel production are soybean, canola/rapeseed, sunflower, cottonseed, palm seed and palm kernel, corn and mustard seed oil. Pork, beef and poultry fat and grease also can be converted to biodiesel. Palm oil and animal fat may have a high free fatty acid content, which causes soap formation that has adverse effects on downstream processing and leads to yield reduction. The blending mandate of 5% ethanol with gasoline in nine states of India in 2003 was enhanced to include 20 states in 2006. In 2010, the National Policy on Biofuels approved a target 20% blending with biofuels by 2017. Wet-land rice cultivation field may be used for micro algae growth as an intercrop with rice without affecting rice yield. Second generation or cellulosic ethanol is produced from agricultural residues containing cellulosic biomass– such as the stalks, leaves, bagasse, and husks of rice, wheat, wood chips, sawdust or energy crops. India has great stock of biomass for cellulosic biofuel production. Praj Industries has finally started construction of second generation cellulose based bioethanol plant in India. At $25 million plant, cellulosic ethanol will be made from agro-waste unlike first generation fuel that is made from food crops.

Government initiatives Government has set up a target of 20% blending by 2017. Apex financial institutions like the National Bank for Agriculture and Rural Development (NABARD), Indian Renewable Energy Development Agency (IREDA) and Small Industries Development Bank of India (SIDBI) have refinancing provisions to set up biodiesel plantations, oil expelling/ extraction units, and infrastructure for storage and distribution. The Bio-Diesel Association of India (BDAI), is a non-profit national association representing the biofuels sector more specifically biodiesel industry as the coordinating body for marketing, research and development in India, encourage biofuels specially biodiesel and assure sustainable agricultural growth, rural development, energy security and equal opportunity for the masses with overall environmental protection. India’s biofuel policy exempts the biofuel sector from central taxes and duties. While biodiesel is exempt from excise duty, bioethanol enjoys a concessional excise duty of 16%. Customs and excise duty concessions are also provided on plant and machinery for the production of biodiesel and bioethanol. The developed nations have already waked up to the call for generating new and renewed energy sources and the developing countries such as India; China etc. should up the ante and show their strong support to the underlined attempts. The U.S. (48%), Brazil (22%), and the European Union (17%) account for 87% of global biofuel production in 2011. Current target of USA is to produce 136 billion of biofuel.

12.3 Impacts of Biofuels

The growth of biofuel production from crops will have a direct impact on the land and the environment writes

12.3.1. Positive impact of biofuel

One of the major reasons for producing biofuels is to reduce greenhouse gas emissions and to mitigate the effects of global warming produced by fossil fuels.

However, according to the Food and Agriculture Organisation of the UN, some unintended impacts of biofuel production are on land, water and biodiversity. They are affected by agricultural production and if the agricultural production is intensified then the side effects are even greater.

The common conception is that growing crops for biofuels will offset the greenhouse gas emissions because they directly remove carbon dioxide from the air. However, the FAO in its The State of Food and Agriculture 2008 report, says that scientific studies have shown that different feedstock's grown for biofuels have different environmental effects."Depending on the methods used to produce the feedstock and process the fuel, some crops can even generate more greenhouse gases than do fossil fuels," the report says. It warns that nitrous oxide that is released from fertilizers that might be put on the ground to help the crops grow will have 300 times more global warming effect than carbon dioxide.

There is also a difference in the greenhouse gas savings of different crops as maize produced for ethanol has an annual greenhouse gas saving of about 1.8 tonnes per hectare according to the report, but switch grass, which is a second generation crop has a saving of 8.6 tonnes.

The FAO says that the amount of emissions produced throughout the production cycle also have to be taken into account and there is a balance to be drawn between the direct greenhouse gas savings, the emissions and the potentially valuable by-products produced in biofuel production.

The balance also has to be drawn between the greenhouse gas emissions produced in the production and burning of biofuels and the production and burning of fossil fuels. These balances can vary between different feedstocks and different locations and production methods.

First-generation biofuels from current feedstocks results in emission reductions in the range of 20-60 per cent relative to fossil fuels, provided the most efficient systems are used and carbon releases deriving from land-use change are excluded," the report says. However, it adds that Brazil has the best conversion rate and the highest savings with typical reductions of between 70 and 90 per cent. One of the most telling impacts of biofuels is any change in land use that might take place. The FAO says the impact is at the beginning of the production cycle and any change in land use might take years to balance out the effects and in some cases could show fossil fuels to be more efficient than the biofuels. This would be particularly relevant is rainforest, peat lands, savannahs or grasslands are used to grow feedstocks to produce ethanol or biodiesel.

The FAO warns that there can be a knock on effect in growing crops especially as feedstock for biofuels. It can displace other crops and create a greater demand for new land for growing new feedstocks. In Australia Canada and the US this has been seen as land that is used as non-cereal crop land at present, in the EU it is set aside land and in Latin America it is new uncultivated land. This land grab to plant biofuel feedstock could see large swathes of land changing its use.
The sugar cane area of Brazil is expected to almost double to more than 10 million hectares over the next decade and along with the expansion of the Brazilian soybean area this could displace lands for livestock pasture and other crops. In the end this places pressure on uncultivated land. Other significant pressures on the land are going to be seen in the intensification of crop production through new technology and impacts on the soil through water use and the potential scarcity of water. This could become a limiting factor in the production of biofuel crops and producing more biofuel crops will also have an effect on the water quality.

i. **Political**

Subsidies and mandatory blending have created an artificially rapid growth in biofuel production, worsening some negative impacts. Existing policies have had a limited effect in achieving energy security and climate change mitigation and therefore need to be reviewed.Government incentives and support for biofuels have been largely guided by national or regional

ii. Environmental

The overall performance of different biofuels in reducing fossil energy use and greenhouse gas emissions varies widely when considering the entire life cycle from production through transport to use. The net balance depends on the type of feedstock, the production process and the amount of fossil energy needed. When forests or grasslands are converted to farmland, be it to produce biofuel feed-stocks or to produce other crops displaced by feedstock production, carbon stored in the soil is released into the atmosphere. The effects can be so great that they negate the benefits of biofuels, and lead to a net increase in greenhouse gas emissions when replacing fossil fuels.

When crops for biofuel production require irrigation, it exerts pressure on local water resources. In addition, water quality can be affected by soil erosion and runoff containing fertilisers and pesticides. Changes in land-use and intensification of agricultural production may harm soils. The impacts depend on the way the land is farmed. Various techniques and the use of certain plant species can reduce adverse impacts or even improve soil quality.

Biofuel production can affect biodiversity. For instance habitat is lost when natural landscapes are converted into energy-crop plantations or peatlands are drained. In some instances, however, biofuel crops can have a positive impact, for instance when they are used to restore degraded lands. In order to ensure an environmentally sustainable biofuel production, it is important that good agricultural practices be observed, and measures to ensure sustainability should be applied consistently to all crops. Moreover national policies will need to recognize the international consequences of biofuel development. The combustion of fossil fuel increases the concentration of carbon dioxide in the atmosphere. The carbon dioxide and other so-called greenhouse gases allow solar energy to enter the atmosphere, but reduce the amount of energy that can re-radiate back into space, trapping energy and causing global warming. However, some biofuels may reduce greenhouse gas emissions, but net effects on climate change depend on where and from what raw materials they are produced. Carbon emissions from land-use change when forest or pasture is converted to cropland can largely negate the greenhouse gas savings obtained by using biofuels for transport.

iii. Socio-economic

Increased biofuels production will be achieved through improved land productivity and through expansion of cultivated area, using existing cropland as well as less-productive land. However, it is more likely that biofuels will intensify the pressure on the fertile lands where higher returns can be achieved.

12.3.2. Negative Impact of Biofuels

Increased biofuel production could come from using more cropland for biofuel production and from improved yields. However, if grasslands or forests are brought into agricultural production for this purpose, this would have environmental consequences. The biofuels policies in place in the EU and the USA, have distorted national and international agricultural markets. This results in high costs for the taxpayers in developed countries and discrimination against producers in developing countries. As a consequence, production does not necessarily occur at the most economically and environmentally suitable locations or with the most efficient technologies.

The positive contribution of biofuel towards energy security and greenhouse gas emission reductions is increasingly being challenged. Their unintended impacts on market prices and food-security have frequently been overlooked in policy discussions. Uncertainties regarding the economic viability of biofuel remain, because of the influence of oil and crop price fluctuations, as well as future policy and technical developments. Biofuel are influenced by a wide range of policies, and a coordinated approach is needed to consider overall benefits and risks. Replacing fossil fuels with biofuel isn't the answer. Replacing fossil fuels isn't even an option current energy use, especially in the industrialized countries, is not sustainable anyway, whatever the energy source.

Biofuels are considered to be a way of reducing the emission of the greenhouse gases. They can also be looked upon as a way of energy security which stands as an alternative of fossil fuels that are limited in availability. However, one of the greatest problems that is being faced by the researchers in the field is how to covert the biomass energy into the liquid fuel.

Fuel such as methane produced from renewable biological resources such as plant biomass and treated municipal and industrial waste.

Large-scale production of biofuels from crops requires large land areas, so liquid biofuels can only replace fossil fuels to a very limited extent. Current production is equivalent to less than one percent of world transport fuel demand.

Biofuels are accused by the UN and others of pushing up world food prices, and exacerbating the effect of the most severe drought in the US in half a century. US legislators called on the environmental protection agency this month to waive its ethanol mandate that stipulates 40% of the American corn crop is turned into biodiesel. The US department of agriculture said the corn yield would be the lowest for 17 years, raising grain prices as it means there will be more demand for wheat to be used as animal feed. Prices for liquid biofuels and for the crops needed to produce them are partly driven by fossil fuel prices. Government support schemes also play a key role as most biofuels are not generally competitive without subsidies, even when crude oil prices are high.

The crop and energy markets are closely linked, since agriculture both supplies and uses energy. Agricultural crops compete with each other for land and water and farmers will sell their produce to markets regardless of end use, be it for biofuel production or food use.

When the market value of a biofuel crop is high, prices for other agricultural crops that also need land and water will tend to rise too. The main drivers of government support for biofuels are concerns about energy security and climate change as well as a political will to support the farm sector.

Food prices generally declined during the 40 years up to 2002, if inflation is taken into account. Since then they have risen sharply, with vegetable oil and cereal prices showing large increases. These high prices are partly the result of rising demand from developing countries and for biofuel production. There have also been poor harvests in some countries at a time when reserve stocks are at a relatively low level. Biofuel demand and supply are expected to continue their rapid increase. And although the share of liquid biofuel in overall transport fuel supply will remain very limited, the projected increase in production of crops for making biofuel is substantial relative to the projected increase in total agricultural production.

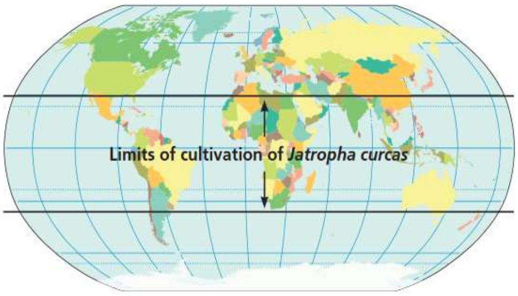
12.4 Biofuel farming

12.4.1. Jatropha

Common name: Ratanjor

Botanical Name: Jatropha curcas

Distribution:



Climate: Jatropha grows in tropical and sub tropical regions, with cultivation limits at 30ºN and 35ºS. It also grows in lower altitudes of 0-500 metres above sea level. Jatropha is not sensitive to day length (flowering is independent of latitude) and may flower at any time of the year (Heller, s during the dry season, with deep roo . While jatropha can survive with as little as 250 to 300 mm of annual rainfall, at least 600 mm are needed to flower and set fruit. The optimum rainfall for seed production is considered between 1 000 and 1 500 mm (FACT, 2007), which corresponds to subhumid ecologies. While jatropha has been observed growing with 3 000 mm of rainfall (Foidl, 1996, cited Achten, 2008), higher precipitation is likely to cause fungal attack and restrict root growth in all but the most free-draining soils. Jatrophacurcasis not found in the more humid parts of its area of origin, Central America and Mexico.

Figure 3. Jatropha curcas

Rainfall induces flowering and, in areas of unimodal rainfall, flowering is continuous throughout most of the year. Optimum temperatures are between 20 ℃ and 28 ℃. Very high temperatures can depress yields (Gour, 2006). Jatropha has been seen to be intolerant of frost. The plant is well adapted to conditions of high light intensity Baumgaart, 2007, cited Jongschaap, 2007) and is unsuited to growing in shade.

12.4.1.1 Soil and soil preparation

The best soils for jatropha are aerated sands and loams of at least 45 cm depth (Gour, 2006). Heavy clay soils are less suitable and should be avoided, particularly where drainage is impaired, as jatropha is intolerant of waterlogged conditions. Ability to grow in alkaline soils has been widely reported, but the soil pH should be within 6.0 to 8.0/8.5 (FACT, 2007). There is evidence from northwest India that jatropha is tolerant of saline irrigation water, although yield under these conditions is not documented (Dagar *et al.*., 2006).

Jatropha is known for its ability to survive in very poor dry soils in conditions considered marginal for agriculture, and can even root into rock crevices. However, survival ability does not mean that high productivity can be obtained from jatropha under marginal agricultural environments.Being a perennial plant in seasonally dry climates, soil health management under jatropha production would benefit from conservation agriculture practices. This would result in minimum soil disturbance, an organic mulch cover on the soil surface and legume cover crops as intercrops.

12.4.1.2. Propagation method

Pre-cultivation in nurseries, sown in either nursery beds or containers, enables better germination and survival of seedlings through control over moisture, shade, soil, weeds, pests and diseases. Seeds should be sown three months before the start of the rains in polyethylene bags or tubes. The bags should be long enough to avoid unduly restricting taproot growth. The use of specifically designed tree propagation cells (e.g. Root rainers) that have internal vertical ribs and air-pruning holes would be beneficial.

12.4.1.3. Crop maintenance

Once established, growth is rapid. The leading shoot may reach 1 m within five months, with all vegetative growth during the rainy season. Trees typically bear their first fruit following flowering in the second rainy season. Before the ground is shaded by the developing leaf canopy, it is important to control competing weeds regularly. The cut weeds may be left as surface mulch. In semi-arid regions, digging contour trenches and basins around individual plants aids water entrapment and infiltration. Pruning during the dry or dormant season is important to increase branching and the number of tip-borne inflorescences, as well as to form a wide low-growing tree that is easier to harvest. The stem and branches may be pinched out at six months to encourage the development of laterals and the main stem cut back to 30–45 cm. The branch tips are pruned again at the end of the first year. In the second and subsequent years, branches are pruned by removing around two-thirds of their length. After ten years, it is recommended to cut trees down to 45 cm stumps to improve yields. Re-growth is rapid and trees will start bearing again within a year (Gour, 2006).Flowers require the presence of pollinating insects. Thus, it may be beneficial to place hives for honey bees in the proximity.

12.4.1.4 Harvesting

Seeds are ready for harvesting around 90 days after flowering when the fruits have changed from green to yellow-brown. In wetter climates, fruiting is continuous throughout the year, while the harvest may be confined to two months in semi-arid regions. Even then, the fruits do not ripen together, requiring weekly picking and making the harvest labour intensive and difficult to mechanize. The yellow and brown fruits are harvested by beating the branches with sticks to knock them to the ground, or by hand picking. The fruits are dried and the seeds removed from the fruit shells by hand, by crushing with a wooden board or by using a mechanical decorticator. Work rates for harvesting are given by Henning (2008a) as 24 kg per workday while India's National Oilseeds and Vegetable Oils Development Board (NOVOD) gives a rate of 50 kg of seed per workday (NOVOD, 2007). The seeds are shade dried for sowing but dried in the sun for oil production to reduce moisture content to around 6–10 percent. If kept dry and ventilated, the seeds may be stored for up to 12 months without loss of germination or oil content, although there may be losses to pests in storage.

12.4.1.5 Yield

Since systematic recording of yields started only relatively recently, it is important to note that there is little data available for seed yields from mature stands of jatropha. Earlier reported yields used largely inconsistent data, and claims of high yields were probably due to extrapolation of measurements taken from single, high-yielding elderly trees (Jongschaap *et al.*., 2007). Individual tree yields are reported to range from 0.2 to 2.0 kg of seed annually (Francis, 2005). On an area basis, Open shaw (2000) reports seed yields between 0.4 to 12 tonnes per ha, and Heller (1996) reports yields between 0.1 and 8.0 tonnes per ha. Mostly, these yield figures are accompanied by little or no information on genetic provenance, age, propagation method, pruning, rainfall, tree spacing, soil type or soil fertility. Heller (1996) and Tewari (2007) suggest that production in semi-arid areas may be around 2.0–3.0 tonnes per ha, though it appears likely that lower average yields are being realized in these sub-optimal conditions.

Potential yields for jatropha in semi-arid conditions in Andhra Pradesh, India, are forecast at 1.0 tonne per ha (Wani *et al.*., 2008). Furthermore, during a 17-year period, jatropha growers at Nashik, India, averaged yields of less than 1.25 tonnes per ha (Ghokale, 2008). On the other hand, with good soil, higher rainfall and optimal management practices, there are reported yields of 5.0 (Achten, 2008), and 6.0–7.0 tonnes per ha (FACT, 2007). Jongschaap (2007) calculated a theoretical potential seed yield of 7.8 tonnes per ha under optimal conditions. Jatropha shows a high variability in yield among individual trees, which is a characteristic of the trees in cultivation being essentially composed of wild varieties. The annual yield variation of 19 trees, shown in Figure 7, range from 0 to 850 grams of dry seed per tree. Clearly, the greatest prospect for yield improvement lies with improving the germplasm.

12.4.1.6 Disease and impact

It is popularly reported that pests and diseases do not pose a significant threat to jatropha, due to the insecticidal and toxic characteristics of all parts of the plant. Observations of free-standing older trees would appear to confirm this, but incidence of pests and diseases is widely reported under plantation monoculture, and may be of economic significance. Observed diseases, such as collar rot, leaf spots, root rot and damping-off, may be controlled with a combination of cultural techniques (for example, avoiding waterlogged conditions) and fungicides. The shield-backed or scutellera bug, regarded as a key pest of plantation stands of jatropha in Nicaragua (Pachyco risklugii) and India (Scuteller anobilis), causes flower fall, fruit abortion and seed malformation.

12.4.1.7 Other uses for the oil

Jatropha oil has molluscicidal properties against the vector snails of the Schistosoma parasite that causes bilharzia. The emulsified oil has been found to be an effective insecticide against weevil pests and houseflies, and an oil extract has been found to control cotton bollworm and sorghum stem borers (Gubitz, 1999). Shanker and Dhyani (2006, cited Achten *et al.*., 2008) describe the use of oil extracts as an insecticide, molluscicide, fungicide and nematicide. These potential uses have yet to be commercialized.

12.4.1.8 Uses of jatropha oil

The production of jatropha biodiesel is a chemical process whereby the oil molecules (triglycerides) are cut to pieces and connected to methanol molecules to form the jatropha methyl ester. An alkali – normally sodium hydroxide (caustic soda) – is needed to catalyze the reaction. Glycerine (glycerol) is formed as a side product. Methanol is normally used as the alcohol for reasons of cost and technical efficiencies. This process is summarized in Figure 9.Sodium hydroxide is dissolved in methanol to form sodium methoxide, which is then mixed with jatropha oil. The glycerine separates out and is drained off. The raw biodiesel is then washed with water to remove any remaining methanol and impurities. Typical proportions used in the reaction are:

Chemical reaction for converting Jatropha oil to biodiesel

Triglyceride + Methanol $\xrightarrow{\text{Sodium hydroxide}}$ Methyl ester (Biodiesel) + Glycerine

For every 1 litre of biodiesel, 79 millilitres of glycerine are produced, which is equivalent to around 10 percent by weight. The raw glycerine contains methanol, the sodium hydroxide catalyst and other contaminants, and must be purified to create a saleable product. Traditional low-volume/high-value uses for glycerine are in the cosmetic, pharmaceutical and confectionary industries, but new applications are being sought as production shifts to high volume/low value. Glycerine is used in the production of fuel, plastics and antifreeze.

The production of biodiesel requires expertise, equipment and the handling of large quantities of dangerous chemicals (methanol is toxic and sodium hydroxide is highly corrosive). It is not a technology suited to resource-poor communities in developing countries.

12.4.2 Farming of Karanj

Karanja (*Pongamia pinnata*) and jatropha (*Jatropha curcas*) are two oilseed plants that produce non edible oils and are not exploited widely due to the presence of toxic components in their oils. *Pongamia pinnata* Syn. *P. glabra* trees are widely distributed through the humid lowland tropics commonly found in India and Australia and also in Florida, Hawaii, Malaysia, Oceania, the Philippines, and the Seychelles.

Figure 4. *Pongamia pinnata*

The karanja is a medium-sized evergreen tree, which has minor economic importance in India. The fruit or pod is about 1.7 to 2 cm in length, 1.25 to 1.7 cm wide, and weighs about 1.5 to 2 g. The seeds are collected manually and decorticated using a hammer. The hulls are separated by winnowing. The karanja seed kernel contains 27 to 39 wt% oil. The oil is extracted from the kernel by traditional expeller, which yields 24 to 26% oil. The oil contains toxic flavonoids such as karanj in and a di-ketone pongamol as major lipid associates, which make the oil nonedible. The oil has been used chiefly for leather tanning, lighting, and to a smaller extent in soap making, medicine, and lubricants. The main constraints to greater use of karanja oil in soaps is its colour and odour, as well as the ineffectiveness of conventional refining, bleaching, and deodorization in improving the quality of the oil (Bringi 1987).

The physicochemical properties of karanja and jatropha oils are listed in Table 18.1.Karanja oil is yellowish orange to brown, whereas jatropha oil is pale yellow in color. Karanja and jatropha oils contain 3 to 5% and 0.4 to 1.1%, respectively, of lipid associates (unsaponifiable matter) responsible for the toxicity and development of the dark color on storage. The fatty acid compositions of both oils are listed in Table 18.2. The karanja oil contains 44.5 to 71.3% oleic acid as the major fatty acid.

Oleic and linoleic acids are the major fatty acid in jatropha oil. *Pongamia Pinnata* trees are normally planted along the highways, roads and canals to stop soil erosion. Billions of trees exist all over India. If the seeds fallen along road side are collected, and oil is extracted at village level expellers, thousands of tons of oil will be available for Lighting the Lamps in rural area. Karanj oil is the best oil for lighting. Since these are spread over a large area, collection of seeds for Bio Diesel manufacture is not viable. (A compact plantation can support a Bio Diesel plant).

Pongamia Pinnata is called as Koroch in Bangladesh. There, Karanj is a fresh water flooded plant / tree. The seedlings of Koroch can survive in 1.5 meters deep water submergence / inundation for five to six months duration at a stretch. There are nearly 30,000 square km of water reservoirs in India. This tree can be cultivated in such water storage reservoirs up to 1.5 meters depth and reap additional economic value from unused reservoir lands.

Pongamia Pinnata is one of the few nitrogen fixing trees to produce seeds containing 30 to 32% oil. Karanj is often planted as an ornamental and shade tree. This specie is commonly called Pongam, Karanj, or a derivation of these names.

12.4.2.1 Botany

Pongamia (Leguminoceae, subfamily Papilionoideae) is a medium sized tree that generally attains a height of about 8 meters and a trunk diameter of more than 50 cm. The trunk is generally short with thick branches spreading into a dense hemispherical crown of dark green leaves. The bark is thin gray to grayish-brown, and yellow on the inside. The tap root is thick and long, lateral roots are numerous and well developed.

The alternate, compound pinnate leaves consist of 5 or 7 leaflets which are arranged in 2 or 3 pairs, and a single terminal leaflet. Leaflets are 5 to 10 cm long, 4 to 6 cm wide, and pointed at the tip. Flowers, borne on racemes, are pink, light purple, or white. Pods are elliptical, 3 to 6 cm long and 2 to 3 cm wide, thick walled, and usually contain a single seed. Seeds are 10 to 20 cm long, oblong, and light brown in color.

12.4.2.2 Ecology

Native to humid and subtropical environments, *Pongamia* thrives in areas having an annual rainfall ranging from 500 to 2500 mm. In its natural habitat, the maximum temperature ranges from 27 to 38^{o}C and the minimum 1 to16^{o}C. Mature trees can withstand water logging and slight frost. This specie grows to elevations of 1200 meters, but in the Himalayan foothills is not found above 600 meters. Pongamia can grow on most soil types ranging from stony to sandy to clay. Karanj does not do well on dry sands. Karanj is highly tolerant of salinity. Karanj is common along waterways or seashores, with its roots in fresh or salt water. Highest growth rates are observed on well drained soils with assured moisture. Natural reproduction is profuse by seed and common by root suckers.

12.4.2.3 Distribution

The natural distribution of Pongamia is along coasts and river banks in India and Burma. Native to the Asian subcontinent, this species has been introduced to humid tropical lowlands in Malaysia, Australia, the Seychelles, the United States and Indonesia.

12.4.2.4 Wood

Pongamia is commonly used as fuel wood. Its wood is medium to coarse textured. However, Karanj is not durable, is susceptible to insect attack, and tends to split when sown. Thus the wood is not considered a quality timber. The wood is used for cabinet making, cart wheels, posts, agricultural implements, tool handles and combs.

12.4.2.5. Oil

A thick yellow-orange to brown oil is extracted from seeds. Yields of 25% of volume are possible using a mechanical expeller. However, for village crushers average yield is 20%. The oil has a bitter taste and a disagreeable aroma, thus Karanj is not considered edible. In India, the oil is used as a fuel for cooking and lamps. The oil is also used as a lubricant, water-paint binder, pesticide, and in soap making and tanning industries. The oil is known to have value in folk medicine for the treatment of rheumatism, as well as human and animal skin diseases. Karanj is effective in enhancing the pigmentation of skin affected by leucoderma or scabies. The oil of Pongamia is also used as a substitute for diesel.

12.4.2.6 Fodder and Feed

Opinions vary on the usefulness of this species as a fodder. The leaves are eaten by cattle and readily consumed by goats. However, in many areas Karanj is not commonly eaten by farm animals. Its fodder value is greatest in arid regions. The oil cake, remaining when oil is extracted from the seeds, is used as a poultry feed.

12.4.2.7 Other Uses

Dried leaves are used as an insect repellent in stored grains. The oil cake, when applied to the soil, has pesticidal value, particularly against nematodes and also improves soil fertility. Pongamia is often planted in homesteads as a shade or ornamental tree and in avenue plantings along roadsides and canals. Karanj is a preferred species for controlling soil erosion and binding sand dunes because of its dense network of lateral roots. Its root, bark, leaf, sap, and flower also have medicinal properties.

12.4.2.8 Agro Practices

Sowing and Germination: Pongamia is easily established by direct seeds or by planting nursery-raised seedlings or stump cuttings of 1 to 2 cm root collar diameter. In peninsular India, the seeding season is April to June, and the seed yield per tree ranges from about 10 kg to more than 50 kg. 1,500 to 1,700 seeds weigh 1 kg., which require no treatment before sowing, remain viable for about a year when stored in air-tight containers. Seed germinates within two weeks of sowing. Seedlings attain a height of 25 to 30 cm in their first growing season.

12.4.2.9 Transplantation: Transplanting to the field should occur at the beginning of the next rainy season when seedlings are 60 cm in height. Seedlings have large root systems. Soil should be retained around the roots during Transplantation. The spacing adopted in avenue plantings is about 8 m between plants. In block planting, the spacing is 5 x 5 meters. Pongamia seedlings withstand shade very well and can be inter planted in existing tree stands.

12.4.2.10 Management

Pongamia should be grown in full sun or partial shade on well drained soil. A relatively low maintenance tree once established, is resistant to high winds and drought but is susceptible to freezing temperatures below 0^{o}C. *Pongamia* will show nutritional deficiencies if grown on soil with a pH above 7.5. Space major limbs along the trunk to increase the structural strength of the tree. Keep limbs less than two-thirds the diameter of the trunk to help ensure that branches are well secured to the tree.

12.4.2.11 Pests

No pests are of major concern, but caterpillars occasionally cause some defoliation. No diseases are of major concern.

You can plant 200 plants per acre in the formation of 5 m x 4 m. You can get yield of 25 to 40 kgs per tree with 30 to 35% oil content. One person can collect 180 kgs of seeds in 8 hours of a day. Seed collection season in India is from December to April. Seed collection cost is Rs. 4 per kg.

12.4.3 Euphorbia

Scientific Name: Euphorbia heterophylla L.

Common Names: English: Mexican fireplant, Milkweed; German: Bechertragende Wolfsmilch; French: Euphorbe hétérophylle

12.4.3.1 Description

Erect annual herb to 1.5 m (4.92 ft), rarely to 4 m (13.12 ft) high.

Characteristic Features

Differently-shaped leaves, very tall plants, containing latex in all parts of the plant.

Stems: Stems hollow, usually with scattered hairs.

Leaves: Leaves ovate to rhomboid, 0.5-5 cm (0.19 - 1.96 inch) wide, hairless above, hairless or with a few appressed hairs below, paler toward the base, margins entire or slightly toothed.

Figure 5. ***Euphorbia heterophylla***

Flowers: Flowers male or female in terminal clusters, each flower-head (cyathium) with a solitary terminal female flower surrounded by male flowers enclosed in a cup-shaped involucres with a solitary conspicuous gland; seeds with 3 longitudinal ridges.

Flowering Period: Feb-May / August.

Fruit: Capsule 3-4 mm (0.118 - 0.157 inch) long, 5-6 mm (0.196 - 0.24 inch) wide, hairless, 3-lobed.

Seeds: Warty, brown or gray, mottled, ovoid, 2.5-3 mm (0.098 - 0.118 inch) long. Germination all year round.

Viability of Seeds: Viability of seeds depends on climate and soil moisture content, in tropical areas seeds are less dormant and viability is less than 3 years.

Propagation: Spread by seeds that are released explosively from ripe pods. One plant produces up to 4,500 seeds, birds and contaminated machinery spread the seeds.

Additional Crop Information

It is found in cultivated crops, vegetables, pastures and wastelands and is particularly troublesome in soybeans, cowpeas, corn and sugarcane.

12.4.3.2 Agricultural Importance

E. heterophylla is distributed in most of the tropical and subtropical areas of the world. Plants can be found from sea level to nearly 1,400 m (3,300 ft) elevation, but it is only a serious weed in warm climates. Plants grow rapidly and often shade out seedlings of crops and are very competitive. They can complete life-cycle within 80 days. The weed can completely cover a soybean crop within 2 to 3 weeks after emergence. Heavy infestations increase grain moisture. The latex is toxic.

12.5 Significance of Biofuels farming

As biofuel is known as an alternative to diesel fuel, there are other uses. Many assume that the material is used just for transportation. But biofuel can provide hydrogen, clean up oil, work as cooking oil and more. Biofuels can work as an alternative to replacing energy needs from vehicle fuel to central home heating. Biofuel farming is the necessity of time as its produce biofuel for the different purposes as following:

12.5.1. Transportation

More than 30% of energy consumed in the United States is used for vehicle transportation. Across the globe, transport takes account of 24% of energy and more than 60% of absorbed oil. This means that over a third of oil is used to operate vehicles. The main problem with alternatives is that solar, wind and other alternative power is not practical for transportation. Experts believe that efficient breakthroughs in practical technology advances are still decades away. In short, biofuel can be turned into a hydrogen steam that is meant to be used in adjoining fuel-cell. More major car brands have already invested in stations for biofuel-powered vehicles.

12.5.2. Energy Generation

As biofuel is known as an alternative to diesel fuel, there are other uses. Many assume that the material is used just for transportation. But biofuel can provide hydrogen, clean up oil, work as cooking oil and more. Biofuels can work as an alternative to replacing energy needs from vehicle fuel to central home heating. In addition to producing fuel for transportation, fuel cells have a power-generating application that is available for electricity. Biofuel can be used to generate power in backup systems where emission matters most. This includes facilities such as schools, hospitals and other forms located in residential areas. In fact, the largest market for biofuel to turn into energy generation for over 350,000 homes from landfill gas in the United Kingdom.

12.5.3. Provide Heat

Bio heat has grown over the past few years. As the primary use of natural gas that comes from fossil fuel, the heat that comes from hydraulic fracturing will lead to the production of natural gas. While natural gas does not need to come from fossil material, it is also able to originate from the recently grown material. A majority of biofuel that is used for heating is substantial. As wood is the most practical method to heat, houses that use wood burning stoves rather than gas or electricity. A blend of biodiesel will reduce the emission of both nitrogen and sulphur dioxide.

12.5.4. Charging Electronics

According to scientists from Saint Luis University, a fuel cell was developed with cooking oil and sugar to generate electricity; consumers will be able to use these cells instead of generating electricity. Consumers may be able to use fuel cells in place of batteries to charge anything from computers to cell phones. While they are still in the process of development, cells have the potential to become a ready source of power.

12.5.5. Clean Oil Spills and Grease

Biofuel is known to be environmentally-friendly, biofuel can also help to clean up oil spills and grease. It has been tested to work as a potential cleaning agent for areas where crude oil contaminated the waters.

The results have also been found to increase the recovery areas and allow it to be removed from the water. Biofuel can also be used as an industrial solvent for cleaning metal, which is also beneficial due to its lack of toxic impact.

12.5.6. Cooking

While kerosene is the most common ingredient to use for stoves and non-wick lanterns, biodiesel works just as great.

12.5.7. Lubricate

Diesel fuel is required to reduce the sulphur concentration as sulphur provides the most lubricity of fuel. This is important when it comes to keeping the engine properly functioning and to avoid premature infection failure.

12.5.8. Remove paint and adhesive

Biofuel can replace the toxic products that are designed to remove paint and adhesives. Biofuel is also considered as the best method for removing non-critical applications.

12.5.9. Create energy when fossil fuel runs out

As the oil supply is starting to run out. This has caused us to question how fuel can be extracted without destroying the environment. Biofuel –will help the government create a stable method of producing energy that is cost-effective.

12.5.10. Reduce cost and need for imported oil

More than 84% of the world's petroleum is used in the United States. Despite the increase in fuel demands, the U.S. has recently started to decrease the need since 2006. This allows biofuels to become the best factor in energy reduction.

Bio-diesel production is in rise day-by-day basis in India as well as foreign countries. The major reason behind the phenomena is the limited amount of petroleum product reservoirs. Oil was the largest contributor to our global energy needs at 33% of total consumption, followed by coal (30%), natural gas (24%), hydroelectricity (6%), and nuclear power (5%). Cumulatively, fossil fuels provided 87% of the world's energy in 2011, which was actually a tiny fraction higher than in 2010 (86.9%). However, if we add nuclear power, fossil fuels plus nuclear power provided 92.1% of all energy in 2010, and declined a tiny fraction to 92.0% in 2011 because of a slight decline in nuclear electricity.

The fast depleting reservoir of fossil fuel has already ringed the alarm bell. The economic growth of India in the range of 5-9% and that of China around 10% has raised question marks on longevity fuel supply in international markets. If effective and forceful steps not taken immediately then in very near future the human society will back to the age of no technology system. However, searching of alternates has been initiated very long-time and recently also started yield positive results. Though, the results are not that much promising in many fields but capable to provide sustained energy resources to the human kind. The sustained and renewable energy sources includes solar, wind, biomass, sea-tide, geo-thermal, nuclear etc. As we are more comfortable using energy from fossil fuel, we would like to replicate the fuel from available renewable sources. So, we can use the fuel in the existing systems (automobiles, industries etc.) without altering the major components. Hence, the bio-diesel gained quicker popularity as a source of renewed energy among the planners, researchers and users.

12.6 Summary

In this unit we have discussed about the conservation of energy and the alternatives of energy. India is one of the fastest growing economies in the world. The Development Objectives focus on economic growth, equity and human wellbeing. Energy is a critical input for socio-economic development. The energy strategy of a country aims at efficiency and security and to provide access which being environment friendly and achievement of an optimum mix of primary resources for energy generation. Fossil fuels will continue to play a dominant role in the energy scenario in our country in the next few decades. However, conventional or fossil fuel resources are limited, non-renewable, polluting and, therefore, need to be used prudently. On the other hand, renewable energy resources are indigenous, non-polluting and virtually inexhaustible. India is endowed with abundant renewable energy resources. Therefore, their use should be encouraged in every possible way.

The common conception is that growing crops for biofuels will offset the greenhouse gas emissions because they directly remove carbon dioxide from the air. However, the FAO in its The State of Food and Agriculture 2008 report, says that scientific studies have shown that different feedstocks grown for biofuels have different environmental effects."Depending on the methods used to produce the feedstock and process the fuel, some crops can even generate more greenhouse gases than do fossil fuels," the report says. It warns that nitrous oxide that is released from fertilisers that might be put on the ground to help the crops grow will have 300 times more global warming effect than carbon dioxide.

Terminal question

1. **(a) Fill in the blank spaces with appropriate words.**
   The Bio-Diesel Association of India (BDAI), is a non-profit national association representing the biofuels sector more specifically biodiesel industry as the coordinating body for…………….., ……………and development in India, encourage biofuels specially biodiesel and assure ………………………growth, rural development, energy security and equal opportunity for the masses with overall………………………….. India's biofuel policy exempts the biofuel sector from central taxes and duties. While biodiesel is exempt from excise duty, ………………..enjoys a concessional excise duty of………. Customs and excise duty concessions are also provided on plant and machinery for the production of biodiesel and bioethanol. The developed nations have already waked up to the call for generating new and renewed energy sources and the developing countries such as India; China etc. should up the ante and show their strong support to the underlined attempts. The U.S. (48%), Brazil………., and the European Union (17%) account for 87% of global biofuel production in…………. Current target of USA is to produce 136 billion of biofuel.

2. **(a) Discuss the production techniques of biofuel.**

   (b) What are the positive impacts of biofuel on environment?

3. **(a) Describe the environmental problems due to biofuel .**

   (b) What is the significance of biofuel farming?

4. Describe the farming techniques of Jatropha plant.

5. (a) Explain the farming system of Euphorbia.

(b)Discuss the biofuel resources of India.

6. a. Fill the blank spaces with appropriate words.

First-generation biofuels from current feedstocks results in emission reductions in the range of ....per cent relative to fossil fuels, provided the most efficient systems are used and carbon releases deriving from land-use change are excluded," the report says. However, it adds that ....has the best conversion rate and the highest savings with typical reductions of between.................... per cent. One of the most telling impacts of biofuels is any change in land use that might take place. The FAO says the impact is at the beginning of the production cycle and any change in land use might take years to balance out the effects and in some cases could show ....to be more efficient than the....................... This would be particularly relevant is........................, peat lands, savannahs or grasslands are used to grow feedstock's to produce ....or biodiesel.

7. (a) More than 84% of the world's petroleum is used in the United States (Yes/No)

(b) *Pongamia Pinnata* is one of the few nitrogen fixing trees to produce seeds containing ……………..oil (30 to 32% /50-60%/70-80%)

(c) What do you understand by Biofuel?

Answers

1 (a) marketing, research, sustainable agricultural, environmental protection, bioethanol, 16%, (22%), 2011

2. (a) See section 12.2.2
(b) See section 12.3.1
3. (a) See section 12.3.2
(b) See section 12.5
4. (a) See section 12.4
5. (a) See section 12.4.3
(b) See section 12.2.3
6. 20-60, Brazil, 70 and 90, fossil fuels, biofuels, rainforest, ethanol
7. (a) Yes
(b) 30 to 32%
(c) See section 12.2

UNIT-13: Repercussions of switching to bio-fuel: The controversy, alternative options

Unit Structure

13.0 Learning Objectives

After studying this unit you will be able to:

a. What are the Repercussion of Biofuel?
b. What is the conflict with biofuel?
c. What are the advantages of biofuel?
d. What are the disadvantages of biofuels?
e. What are the Environmental effects of biofuel?

13.1. Introduction

According to Giampietro et.al (1997) and Demirbas (2007), a biofuel is any type of liquid or gaseous fuel that can be produced from biomass substrates and that can be used as a partial substitute for fossil fuels, predominantly used for the transport sector. Ethanol, methanol and biodiesel are the best example of biofuel. Biomass has been recognized as a major world renewable energy source to further decline fossil fuel resources (Demirbas, 2007). Three main reasons explain the statement: a) it is a renewable resource that could be developed in a sustainable way in the future; b) it appears to have clearly positive environmental properties resulting in no net releases of carbon dioxide (CO_2) and very low sulfur content; c) it seems to have significant economic potential giving the fact that fossil fuel prices rise in the future.

From the market point of view ethanol is widely adopted liquid biofuel (Demirbas, 2007). Ethanol is an alcohol fermented from sugars, starches or from cellulosic biomass. Most of the total amount of ethanol disposed for commercial use is extracted from sugar cane or sugar beet, employing the cheapest means of production. The use of ethanol goes beyond its appliance as a renewable energy fuel source, as well is employed for the manufacture of cosmetics, pharmaceuticals and also for the production of alcoholic beverages. Bioethanol is a petrol additive or substitute and it provides an alternative to reduce both the consumption of crude oil and environmental pollution. The production of biofuel from oil seeds is the second traditional type around the globe. According to Demirbas (2007), biodiesel is an environmentally friendly alternative liquid fuel that can be used in any diesel engine without modification. In the modern time an interest have rised in the recycling of vegetable oils to make biodiesel as it has eco friendly nature in comparison to conventional petroleum or diesel fuel. Bio-ethanol and biodiesel are both produced from classic agricultural food crops that require high-quality agricultural land for growth. Below the resources of the main liquid bio-fuels for automotives are depicted.

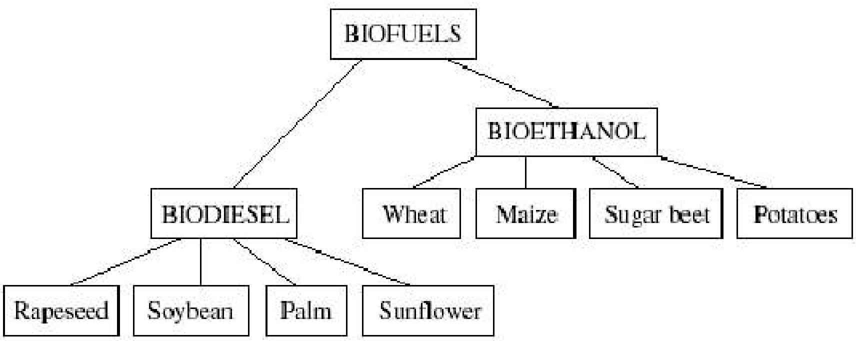


Figure 1: resources of main liquid biofuels for automotives **Source: Demirbas, 2007**

In the biofuel sector, there are two types of biofuel namely first and second generation biofuel. First-generation biofuels are made from food crops and are mainly recognized on the market as ethanol, used for gasoline fuelled vehicles, and vegetable oil, pathway to bio-esters. Ethanol is made by fermenting plant sugars produced by plants, such as sugar cane and corn. Bio-esters are produced by a chemical reaction between vegetable oil (e.g. rapeseed or soyabean oil) and an alcohol. The properties of bio-esters are very close to those of diesel fuel and the two can be mixed. This mixture is known as biodiesel (www.shell.com, 2007).

Second-generation biofuels are made from non-food feed stocks, for example waste from agriculture and forestry. This generation, not competing with crops, can offer better types of engine performance and also decrease CO_2 production. An example is cellulosic ethanol. When commercialised, the cost of second-generation biofuels present similar standards to petrol and diesel (www.shell.com, 2007).

All in all, biofuel became of worldwide interest, representing the potential substitute to petroleum-derived products. The feedstock for bio fuels is more equivalently dispersed, meaning that they are available in every country. Besides, the heavy reliance of most of the countries on few oil supplier markets, provides biofuel a higher level of attractiveness, offering an alternative way to secure energy supply (Esmap, 2005). In addition biofuels are seen as a way to reduce greenhouse gas emissions, finally diversifying energy sources, i.e. “The substitution of gasoline and diesel with biofuels has the added advantage of addressing global climate change” (Esmap, 2005:13). However, it can be questioned that whether the advantages mentioned above outweigh the drawbacks for developing counties emerging from the production of biofuel. Ayre (2007) argued that biofuel might leave the poor hungry and can be seen as a shaping part of the ‘perfect storm’ of poor harvests, rising oil prices and the rush in demand for food in India and China. In these countries, this rush is increasing the price of everything from pasta to a loaf of bread. In Mexico, anger arose due to higher prices of corn flour, leading to ‘tortilla riots’. Downsides occur for the food sector in the developing countries. It is even suggested that the supposed green fuel put the one billion starving people on this planet in contest with the one billion motorists. The food versus biofuel conflict is a stormily debated issue concerning the civil society and market.

13.2 The Conflict

The utilization of biofuels as an alternative energy resource brings along many consequences in biofuel producing developing countries. Positive and negative effects arise in the economic market as well as in the civil society. The challenge arising from this conflict is aimed at finding a balance between the positive and negative consequences of the production and utilization of biofuels in developing countries producing it.

To analyze the conflict at hand, major assumptions have been formulated about biofuel and civil society:

-Biofuel is considered and analyzed as a sustainable alternative to fossil fuels

-Biofuel is assumed to be the solution to the future lack of energy supply.

-Civil society is referring to citizens of developing countries, as considered the main victim arising from the conflict. However in the last part of the paper, NGO's will also be taken into account, representing a potential solution to the problem.

13.3 Dependency on Biofuel

The first sphere of the societal triangle (Van Tulder with Van der Zwart, 2006) to take into account is the civil society of developing countries where biofuel is being produced. Both positive and negative impacts of the production and use of biofuels will be assessed. Biomass in those countries is the major source of energy utilized (Mahapatra and Mitchell, 1999). The dependence of rural population on bio fuels has its effects on forest and agricultural systems. When taking civil society of the developing countries into account, tradeoffs have to be made between poverty, food security and environmental sustainability.

In the table below some figures on bio fuels for domestic consumption in developing countries are shown, to spot the importance of bio fuels.

Table 1 domestic consumption in developing countries

China	20% of gasoline consumed contained ethanol in 2005
Colombia	10% ethanol in gasoline targeted

India	5% ethanol in certain states if ethanol is not more expensive, biodiesel purchase policy
Indonesia	3% of energy from plant-based fuels by 2025
Malaysia	Biodiesel from palm oil
Philippines	Coco-biodiesel, ethanol planned
Thailand	Explosive growth of ethanol-gasoline blend

Source: ESMAP, 2005

13.3.1 Advantages

The advantages in the civil society sector for developing countries consuming and producing biofuel, can be grouped into four categories:

- Employment, Security of energy supply, Health, Biofuel as an environmental sustainable alternative

13.3.1.1 Employment Opportunities

First of all, the increased production of biofuel can offer major new markets to agricultural producers, based on maize, sugar, cassava, oil palm and other crops (www.worldbank.com, 2007). This has a positive effect on civil society, originating in more employment opportunities in rural areas. The production of traditional biofuel is highly laborious. As a consequence, this will be a source of formal and informal employment. Modern production of biofuel is also labour intensive, especially when comparing it to the production of energy from fossil fuels. As a result, new small and large-scale agro-industries will arise in developing countries. Besides, supportive industries, e.g. feedstock and biofuel logistics, will develop at the same pace of biofuel markets. This job-creation potential brings positions like highly skilled science, engineering, business-related employment, medium-level technical staff, low-skill industrial plant jobs and unskilled agricultural labour. Most of these jobs would be created in rural areas, as the majority of the employment will be farming, transportation and processing. In these rural areas, underemployment is a common problem (UN Energy Report, 2000).

According to the report of ESMAP (2005), job creation in rural areas, as a positive consequence due to the increased production of biofuel, can become part of a policy package when government subsidies or other support measures are required for biofuel production. This way, gross income inequality can be reduced and poverty can be alleviated. More job creation can take place in feedstock production, biofuel manufacture and in the transport and distribution of feedstock and products.

13.3.1.2 Security of Energy Supply

Additionally, according to Ryan et.al (2006), another main advantage of biofuel is the increased security of energy supply it provides. High dependence upon oil imports from the political unstable Middle East gives concerns about price variations and possible disruptions in supply. Differentiation of product portfolio in the energy industry sector would provide more secure energy supply. In Brazil, for example ethanol has displaced gasoline with more than 50 percent in the late 1980. Government intervention is protecting liquid biofuel market due to the risk of exhaustibility that those resources incur in the long-run, and the rise in prices that will most likely reach in the near future. Thus, less dependence on petroleum or even self-sufficiency in fuel supply in the form of domestic production of biofuels has been aspired (ESMAP, 2007). When countries become self-sufficient, civil society does not have to fear the scenario of increasing oil prices.

13.3.1.3 Health

Poorest households in the world are heavily dependent on basic energy services rather than on energy for transportation matters. Basic energy services include heat for cooking and power for processing food. Traditional uses of biofuel, i.e. direct burning of wood and other biomass, affects health. As women are overwhelmingly the primary caretakers of the house, this health issue relates to the disempowerment of women as a gender group. Modern biomass derived cooking fuels can reduce harmful indoor air pollution, leading to less diseases (UN Energy Report, 2000). A serious public health risk arises when energy for transportation comes from leaded gasoline, which is still common in some developing countries. Severe diseases can occur from this risk, e.g. neurological effects, high blood pressure, heart disease, etc. (UN Energy Report, 2000). The costs of phasing out lead from this kind of gasoline are high. However, health far outweighs these costs. Modern biofuels do not consist of lead, hence these expenses of phasing out lead will be saved and the health risks will be averted (ibid).

13.3.1.4 Environmental Benefit

Further advantages deriving from biofuel having an impact on civil society, are that these are environmental friendly contributing to global sustainability (Demirbas, 2007). According to the report of ESMAP (2005), biofuels may be environmentally preferable to petroleum-based fuels, as the latter contributes to poor urban air and water quality. According to the same report, biofuels reduce greenhouse gas emissions in the transport sector, especially if the conversion of cellulosic materials to ethanol can be carried out on a commercial scale. Ethanol from sugarcane in Brazil already saves large emissions of greenhouse gases.

Reduction of emissions of local pollutants is also forecasted (ESMAP, 2006). All biofuels are sulfur-free. In developing countries, vehicles are often old. In this case, ethanol has the greatest air-quality benefits. It also helps to reduce the exhaust emissions of carbon monoxide and hydrocarbons. Ethanol can substitute damaging lead additives for raising the octane of gasoline. Biodiesel reduces emissions of carbon monoxide, hydrocarbons, and particulate matter; however, it can slightly increase emissions of nitrogen oxides.

13.3.2 Disadvantages

Besides the positive effects of the production of biofuels on the civil society of the developing countries, there are also some major disadvantages. A worrying example is provided by the production of biofuels in Brazil (Energy Working Group, 2006). Brazil has been exploiting its natural resources since the 16th century, in order to sell them to foreign countries. Nowadays, sugar cane and soy (used for biofuels) are being cultivated in a system of monoculture in enormous quantities. Impacts of this monoculture have grown of the past years, which have developed in turn consequences on the Brazilian civil society. Drawbacks applying to the case and in general to the current situation in developing countries can be grouped into four main areas:

- Food security, divided into two dimensions: food access and food availability, Environmental concerns, Health and impacts on employment

A. Food Security

The expansion of biofuel production has an impact on the food security different levels: household, national and global. This will primarily depend upon the increased production of liquid biofuels used for transportation, derived from food crops feedstock. Two main dimensions concerning food security are dealt with in this section: food access and food availability.

B. Food Access

A drawback of the production of biofuels arises because of the pressure on food prices from both the demand and supply side. On the demand side, some uncertainties are leading to higher food prices. One uncertainty concerns the rapid expansion of biofuels produced from agricultural feedstock. It can be indicated that the real price increase for maize will be around 40 percent by 2020. Substitute grains, like wheat, will be influenced by this price increase, given rapid growth in biofuels demand. However, in order that biofuel stays competitive in the long run, the prices of feedstock, like maize and sugar, cannot rise faster than real energy prices. The uncertainty that subsequently arises relates to the price of oil, technical progress in the efficiency of converting agricultural feedstock and biomass and the size of government subsidizes (www.worldbank.com, 2007).

On the supply side, energy prices will rise, as agricultural production is fairly energy intensive. In the production process of agricultural commodities, energy is an important input used for machinery and fertilizers. Hence, rising energy prices will lead to higher commodity prices and therefore increase food prices. This price relationship will be strengthened when more agricultural commodities will be used for the production of biofuel. As a consequence, the instability of food prices will increase, decreasing food security for the poor (UN Energy Report, 2000). Fertilizer costs in the developping countries are also contributing at rising food prices (www.worldbank.com, 2007).

Due to the impacts of the demand and supply side, high energy prices with more biofuel production from food crops could lead to food crop price increases. Also, global warming could occur faster and the hitting irrigated agriculture with lower yields could add to water shortages (www.worldbank.com, 2007).

C. Food Availability

High quality land, water and other productive resources are needed for the production of biofuels. This means that these resources are diverted away from food production, which in turn leads to threatened availability of sufficient food supplies (UN Energy Report, 2000).

Hence, for low-income food-deficit countries, it is important to consider the long term impact on land availability for food production (ESMAP, 2005). Developing countries are becoming more and more populated, seeing urbanization reducing available land for agriculture.

D. Environmental Issues

Although biofuel is generally considered to be a renewable energy source, according to Jacobson (2004), biofuel is only partly renewable. The burning of biomass releases gases (e.g. CO2) and aerosol particle components (e.g. black carbon and organic matter) (Jacobson, 2004) resulting in a CO2 increase in the atmosphere. The emissions of CO2 from biofuel use in the developing countries are estimated around 50% of the total worldwide CO2 emissions from fossil fuel use. The emission of CO2 from burning of biofuels, even if partly limited, is significant when compared with the emissions of CO2 from fossil fuel use and industry (Yevich and Logan, 2003). Furthermore in the developing countries like in Africa, there is a serious environmental concern due to the deforestation. For example, in both urban and rural areas in Ethiopia, like in many other developing countries, there is a heavy dependence on fuel wood and on the traditional biofuel sources due to the growing population. Deforestation brings along many consequences: "loss of biodiversity and genetic resources, soil degradation, depletion of water resources, disturbance of microclimates, loss of wildlife resources and impediment to the cycling of carbon" (Bewket, 2003:378)

Contamination of the soil, rivers and spring waters is the last concern involving environmental matters. This contamination is caused by the disposal of waste, high use of chemical products in monoculture areas and due to deforestation (Energy Working Group, 2006).

E. Health Issues

According Ludwig et al. (2003), biomass burning has important impacts on atmospheric chemistry and climate. Large quantities of trace gases are being released from fires in tropical forests and savannas. Burning of biofuels for cooking and heating constitutes a less but likewise widespread biomass burning activity. Most of this domestic biomass burning takes place in the developing world, as biofuels are needed because of economic reasons. Furthermore, the study of Mishra and Retherford (2007) suggest that there is a strong relationship between biofuel use and risks of anaemia and stunting in children, suggesting that exposure to biofuel smoke may contribute to constant nutritional shortage in young children. Besides, the health of farmers and the population in nearby areas are threatened due to the intensive use of agrotoxics and other agrochemicals. This mainly takes place during pulverization by airplanes (Energy Working Group, 2006).

F. Employment issues

Contrary to the report of ESMAP as discussed in the advantages that arise with the production of biofuel, according to the Energy Working Group (2006), biofuel production hardly creates jobs due to the monoculture activities. Those rural activities used for the production of biofuel occur most of the time in great properties. Rural workers will move to the periphery of the cities, due to monoculture and expulsion, leading to urban and rural poverty. Also according to the UN Energy Report (2000), in the case that large-scale, mechanised farms arise, as a consequence workers might be displaced. Besides, with large-scale agricultural plantations often poor labour conditions are involved (ibid). Small farmers are being violently removed from their land, latifundio owners (e.g. have more than a thousand hectares of land), accounting for 3 percent of the rural properties, take up 56.7 percent of the lands destined for agriculture (Energy Working Group, 2006), driving the world's poorest farmers off their land and into deeper poverty (UN Energy Report, 2000).

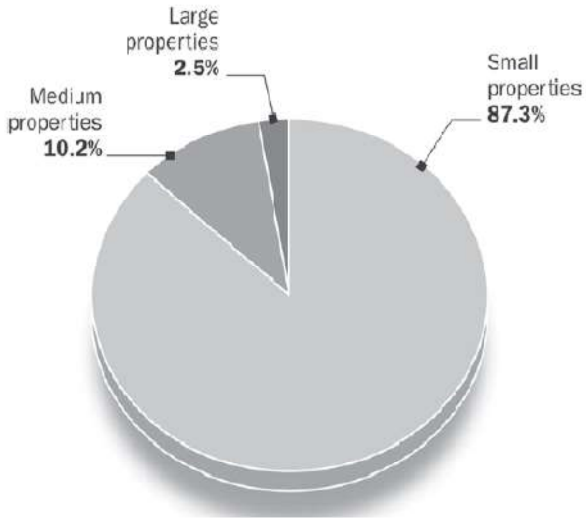


Figure 6: Creating jobs in rural areas **Source: Energy Working Group, 2006**

Different studies predict potential scenarios that will develop in the future concerning the biofuel industry sector. Positive and negative impacts of the growth of biofuel energy are considered. Generally, the shift of the industry from the utilization of fossil fuel to biofuel, is considered as a major threat for developing countries, causing them great damage and worldwide economic misbalance. Projection of future food supply and demand, the subsequent use of biofuel in developing countries and a general increase of such resource worldwide, is hereby discussed taking several documents into consideration. The reports analyzed are mainly emitted by The United Nation Food and Agriculture Organization (FAO) and the Food Agricultural Policy Research Institute (FAPRI).

13.4 Overcome to the conflicts of biofuel

In order to balance the conflict that arises between civil society and market, the interrelationships among the two spheres will be taken into account. When implementing large-scale biofuels, particular attention should be addressed to the following issues: a) land availability and tenure; b) impact on rural communities and economies; c) environmental impacts and sustainability; d) economic feasibility; and e) technical questions of species, mixtures and management systems (Paustian et al., 1998). Additionally, as Hill et al. (2006) argue, biofuel can be a feasible alternative only if it provides a net energy gain, has environmental advantages, is economically competitive, and finally if it is producible in large quantities without reducing food supplies. Several possible solutions will be given in order to overcome the disadvantages of producing and using biofuel for the civil society and market.

a. **Civil Society Intervention**

NGO's and non-profit organization have been struggling trying to provide solutions to this conflict of interest. Alternative ideas have been approved and soon to be tested and applied to the market.

b. **International bio energy platform**

FAO engaged in extensive researches in the field of biofuel, delivering to its members 'countries an "International Bio energy Platform", to help them and assist them in decision making process. Through this platform, FAO is seeking to ensure the delivery of sustainable and accessible bio energy sources and services, supporting at the same time major issues which developing countries are facing (e.g. sustainable development, energy security, poverty reduction and climate change mitigation) (FAO Report, 2006). The aim of such tools is to deliver a helpful base through which stakeholders can interact, energy services from which to access to biofuel systems are enhanced, exchange of information is facilitated, issues and new technologies about biofuel can easily be investigated, and finally interaction and collaboration among partners is fostered (ibid).

c. Global Village Energy Partnership (GVEP)

GVEP aims to promote social and economic development in rural and peri-urban areas of developing countries via increased access to appropriate modern energy services (www.gvepinternational.org). GVEP has been supporting and helping developing countries to set up energy action plans, also providing financial support and technical assistance to energy small-medium enterprises in developing countries (ibid).

d. Overcoming the problem of food security

The soil quality with regards to agronomic productivity and ecosystem services, can be negatively influenced by the removal of crop residues for the use of biofuel. Hence, according to Lal (2006) feedstock for biofuel production should be produced on specifically identified land like surplus or marginal croplands, degraded soils or wastelands, instead of removing crop residues. Biofuel plantations of switch grass, poplar, willow and mesquite can be converted into synfuel hydrocarbons or cellulosic ethanol on lands with no or low fertilizer, pesticides or energy inputs. This option is thought to become cost competitive through improved pre-treatments, enzymes and conversion factors. This way, the problem food security of civil society will be resolved.

To avoid the disadvantages from producing first-generation, i.e. food-based biofuel, the alternative might be to produce second-generation biofuel for transportation usage, such as hydrocarbons or cellulosic ethanol. Those substances can be produced from low input biomass grown on agriculturally marginal land or from waste biomass. This could provide much greater supplies and environmental benefits (Hill et al., 2006).

e. Overcoming the risk for small medium enterprises

An option to improve the quality of life of the population is producing biofuels from plants cultivated by family agriculture, without the use of agro toxics and in a regime of crop rotation. However, this will only succeed when public policies will not benefit agribusiness and businessmen. This new initiative of biofuel cooperatives involve small-scale farmers that plant for energetic and continuation purposes (Energy Working Group, 2006).

f. Government Intervention

The production of biofuels in industrial countries has developed with large subsidies and high protective tariffs. Such policies are disadvantageous for developing countries that could become profitable in exporting biofuels. The major challenge that governments of developing countries are facing, is avoiding to support biofuels through distortionary incentives, at the same time implementing regulations and policies and certification systems to reduce environmental risks (Worldbank, 2007).

Second-generation technologies, including small-scale biodiesel production have higher potential than first-generation technologies. The government's task is to carefully review economic, environmental and social benefits and the potential to increase energy security (www.worldbank.com, 2007). In order to increase the benefits to the poor and to the environment, a framework is needed to support sustainable production of biofuel (UN Energy).

Additionally, CO2 emitted from biomass burning is considered recyclable and biomass particles are thought to cool climate. This is why the Kyoto Protocol did not consider biomass-burning controls. However, since biomass burning and burning grassland and cropland for the production of biofuel leads to CO2 accumulation, such control may slow global warming and improve human health (Jacobson, 2004).

g. **Global Bio-energy Partnership**

This partnership was created in 2005 after the G8, due to the need of promotion and continuation of the development of biofuel energy. Belonging to this partnership are many representatives coming both from the public sector as well as the private one and civil society. The main purpose of this affiliation is to provide a forum to develop effective policy frameworks. This means: facilitating a global political forum to promote biofuel, encourage its production, and enhance the marketing and use of green fuels, finally particularly focusing on developing countries (www.globalbioenergy.org). Extensive information and data about the effects caused by the increasing use and production of biofuel based sources of energy on developing countries have been extensively discussed and argued.

Several stakeholders have been taken into account while discussing potential benefits and drawbacks from the use of those resources. Primary emphasis has been placed on civil society and market, considering the effect of their interaction at the interface between the two spheres as well. The state has been regarded as regulatory body and judge of the conflict, influencing both civil society and market through laws and regulations.

The table below provides a clear representation of the several implications previously discussed, highlighting advantages and disadvantages both from the market side and civil society perspective.

Table 2: Advantages and disadvantages of biofuel to the society and market

	Advantages	**Disadvantages**
Civil society	Employment opportunities, due to new labour intensive agricultural markets	Decreasing food security: food access and food availability
	Security of energy supply	Environmental concerns, e.g. emission of CO_2, deforestation and contamination
	Improved health from cleaner biofuel	Risks for health from indoor use of biofuel and toxics
	Environmentally sustainable, e.g. reduction in emissions	Impacts on employment due to monoculture
Market	Increase of world trade, benefiting developing countries	Block of industrialized countries' economy by regulation and trade restrictions
	Rural development	Uncontrolled urbanization
	Decrease in goods prices	Increase in goods prices due to growth

		in demand and shortage of supply
	Agricultural and biofuel industry increase	Risk for SMEs
	Energy opportunities	Threat to local food sector
	Employment opportunities and well-being	

Several solutions and suggestions have been provided. Future actions undertaken by major bodies from the civil society, market and state sectors have been shortly presented. Platforms, forums, organizations, and partnerships have been formed by major institutions. The aim at reaching higher knowledge in the biofuel sectors, at delivering greater support and commitment to the social and economic development of developing countries, at introducing effective policy frameworks, has been acknowledged as primary function provided by tools such as: International bioenergy, platform, GVEP, GBP, provided both by the state, NGOs and at the market level. Further solutions are found at the market level in the agricultural area. Feedstock of biofuel on specifically identified land is suggested to overcome the problem of food. In addition, the utilization of second-generation biofuels would reduce the impact created on food-based biofuel, as these kinds of biofuel are extracted by cellulosic ethanol, preventing negative effects on the environment and its citizens. The government should finally carefully review economic, environmental and social benefits and the potential to increase energy security, avoiding the support of biofuels through distortionary incentives.

As the above solutions show, the conflict that arises at the interface between market and civil society can be balanced through civil society, market and government interventions. Governments have the responsibility to intervene in and can influence the conflict through rules and regulations on biofuels and the creation of forums. The market can influence the bio-energy production and supply by using an alternative way of production and shift the focus of the production. Finally, the civil society has an influence on the conflict by building up communication channels and facilitating hubs to make the exchange of experiences and support possible. The three spheres of the societal triangle are interrelated and therefore it is necessary that all stakeholders within these spheres are proactive towards the problems that arise at the interface of the market and civil society, so that in the end all can benefit from the biofuel market.

Considering the solutions and the suggestions discussed in section 5 provided by the state, civil society and market, we conclude upon the need in society to create knowledge sharing platforms among the three spheres of the societal triangle. Creation of these platforms will deliver a helpful base through which stakeholders can interact, facilitate the exchange of information and foster interaction and collaboration among partners. Sharing of and access to information is essential in order to support a sustainable development of the biofuel industry in developing countries, thus restraining the negative consequences that may arising from the conflict at hand. This can be realized when different networks from market, civil society and state are open and interrelated, and access to knowledge is made available. Therefore, the Knowledge Economy and Open Society ideology (Van Tulder, 2007) are central to the creation of the knowledge sharing platforms. The general availability of information and diffusion of correct knowledge about biofuels, is seen as the end responsibility of the state. Therefore, in our view governments have the task to promote the correct implementation and production of biofuel in a sustainable-responsive way. By using knowledge sharing platforms the first steps of communication between the different stakeholders and the promotion of sustainable biofuel production is undertaken. Differently, another way of dealing with the promotion of the industry is through the use of campaigns, advertising the use of biofuels, its requirements and method of productions beside public knowledge on biofuels, rules and regulations are also of major importance to overcome the conflict.

Since the search for renewable energy is a global issue, international organizations, like the United Nations, have the task to create and implement policies, regulations and environmental treaties, such as the UNFCCC (United Nations Framework Convention on Climate Change). These regulations are especially necessary on biomass burning, since many poor households in developing countries rely on this energy source. By creating and implementing these regulations, it is possible to decrease the pollution from biomass burning and consequently decrease the negative impacts from it. Furthermore, feedstock of biofuels should be carefully produced in areas such as wastelands, where no implication with food-based production may arise, thus worsening the living condition of the citizens. The government has the responsibility to assure that the population has public access to basic resources, which includes energy and food. Assigning parts of land used exclusively for biofuel production and providing rules and regulation this allocations therefore in our opinion a main task for the government of developing countries. Endeavours

13.5 Alternative Options of biofuel

Biofuel is the example of non conventional fuel. The alternative fuel classified as the fuel that is not the part of conventional fuel like coal , petrol, natural gas. The main objective of the fuel is to store energy for use later. The alternative fuel came into existence as world started to face problem of limited supply of natural resources. The burning of various fossil fuels relase a huge amount pollutant loaded gases, which cause the harmful impact in the form of green house effect, global warming etc.

Petroleum is the main polluter in green house gas emission and affects negatively to the environment. As the demand of petroleum or diesel is rising, in the same way prices of these oil are also hiking, these hiking price of conventional resources directly indicate the increasing demand of the resources.

Various nations have shown an interest to store or tap the renewable energy resources. These resources are environment friendly and not harmful for the environment. So the global demand for solar power, wind power and tidal power is increasing day by day. As the demand is increasing day by day, this is the necessity of time to find the alternative options for biofuel. In the alternative options for biofuel, there is hydrogen energy, air engine etc.

13.5.1 Hydrogen energy

It is believed that hydrogen can play a pivotal role in solving the energy problems of the world. The efficient extraction of chemical energy, which stored in hydrogen, is possible. But due to the less deposit of hydrogen, make it non convenient. Whatever little quantity of the gas is found on the planet also resides in the upper layers of the hemisphere. Hydrogen to be brought into use should be first produced using some other form of energy which is a great threat.

13.5.2 Air engine

The compressed air (after conversion in liquid form) may be used as a fuel. Compressed air is cheaper and available in higher amount in comparison of other fuel. This type of fuel is very easy to handle and environment friendly.

There is now a wide acceptance for crop-based biofuel as wheat, maize, sugar, palm etc. – often called first or current generation biofuels, are causing serious social and environmental impacts. These include increasing GHG emissions, fuelling hunger by diverting food into fuel and causing land grabs in developing countries. This issue has now been consiodered by the European community; "It is wrong to believe that we are pushing food-based biofuels," the commissioners said. "In our upcoming proposal for new legislation, we do exactly the contrary: we limit them to the current consumption level that is five per cent up to 2020." In other words, they are proposing that the amount of food-base biofuels (i.e. sugars, cereals, oil seeds and palm oil) that can count towards the RED 10% target should be capped at 5%. The remaining 5% would have to come from other renewable sources or advanced generation biofuels. They are also proposing to introduce indirect land use change (ILUC) GHG emission factors. Action Aid welcomes this move by the Commission.

13.5.3 Biofuel from wastes and by-products

According to the Department for Transport (DfT), these were the amounts of transport biofuel from waste cooking oil, tallow and bio methane (from sewage and other wastes) in 2011. This includes large amounts of imports. The DfT also cite a report by the environmental consultants AEA Technologies about the likely maximum domestic production of used cooking oil and tallow.

13.5.4 Electrified transport

The Committee on Climate Change (CCC) suggest that battery electric and plug-in hybrid cars could, with proper support, reach 1.7 million by 2020. This would be 5% of all cars on the road, and 16% of new cars that year. This would lead to a 3% reduction in CO_2 – about 0.8% from direct replacement of fossil fuels with renewable electricity, and a further 2% from the fact that electric cars use far less energy per km than fossil fuelled vehicles (this is included in the 15% demand reduction mentioned earlier). The CCC is upbeat about the Government's current initiatives to promote electric vehicles: the plug-in car grant, the Plugged-In Places pilot charging schemes, and the Electric Charging Strategy. However, they are concerned about the changes that took place in the most recent Budget: "Budget 2012 announced that from 2015/16 zero and ultra-low emission cars will no longer be exempt from Company Car Tax, or from Business Cars First Year Allowance (for leasing firms)…Given the promise of this sector, the need for early take up of electric vehicles, and the very limited revenue generated by the Budget changes, we strongly recommend that the Government should reverse this decision. The Company Car Tax and Business Cars First ear Allowance exemption for electric vehicles should be extended to support the development of the electric vehicle market."

13.5.5 Biofuels from other wastes and residues

"Sustainable" second generation biofuels don't yet exist on any useful scale but small quantities particularly from other existing waste streams - may be available by 2020. To meet the 10% target, and assuming the UK carries out all the other measures above and if the quadruple waste counting comes into effect as proposed in the new Commission proposal, an extra 22.7 Petajoules (PJ) of waste energy would be required to get us the rest of the way to the 10% target.

In theory, there's quite a lot of waste energy out there. Food waste could be anaerobically digested to produce methane although this preferentially should be burnt to produce electricity. According to a 2011 IEEP report, the UK could in theory produce 282 PJ from "Genuine residual wastes" (ie landfill and food waste), 46 PJ from "arboricultural arisings" and 114 PJ from "Agricultural and forestry residues". That's 442 PJ of energy. However, it's not quite that simple, because:

• Much of this energy is in the form of wood, energy crops, forestry residues or agricultural straw, which isn't easy to transform into vehicle fuel and costly to transport;

• Transport fuel is not the most sustainable use for much of this waste – it would be better used for heating, electricity generation, soil improvement, or other purposes entirely (from animal bedding to building materials). That said, small quantities of such biofuels could be targeted at sectors where there are few other low-carbon options such as aviation or shipping;

• There's a risk that creating demand for waste as a fuel can reduce the incentive to reduce waste in the first place – and reducing waste always saves more energy in the long term. As with all wastes, the primary focus should be on waste avoidance, then recovery, and finally disposal. In the waste management hierarchy, energy-from-waste comes fairly low down. Materials may have other more sustainable uses and have all sorts of unintended knock-on effects. For example, animal manure or straw, in part, maybe also be an important component for reuse and recycling on the farm and forestry residues should either be left in situ to replenish forest soils or the carbon should be locked away, e.g. reused in the board industry.

13.6 Summary

In this unit we have examined various aspects of biofuel and its related problems so far you have learnt that, a biofuel is any type of liquid or gaseous fuel that can be produced from biomass substrates and that can be used as a partial substitute for fossil fuels, predominantly used for the transport sector. Ethanol, methanol and biodiesel are the best example of biofuel. Biomass has been recognized as a major world renewable energy source to further decline fossil fuel resources (Demirbas, 2007). Three main reasons explain the statement: a) it is a renewable resource that could be developed in a sustainable way in the future; b) it appears to have clearly positive environmental properties resulting in no net releases of carbon dioxide (CO_2) and very low sulfur content; c) it seems to have significant economic potential giving the fact that fossil fuel prices rise in the future.

Biofuel is the example of non conventional fuel. The alternative fuel classified as the fuel that is not the part of conventional fuel like coal , petrol, natural gas. The main objective of the fuel is to store energy for use later. The alternative fuel came into existence as world started to face problem of limited supply of natural resources. The burning of various fossil fuels relase a huge amount pollutant loaded gases, which cause the harmful impact in the form of green house effect, global warming etc.

Petroleum is the main polluter in green house gas emission and affects negatively to the environment. As the demand of petroleum or diesel is rising, in the same way prices of these oil are also hiking, these hiking price of conventional resources directly indicate the increasing demand of the resources. Various nations have shown an interest to store or tap the renewable energy resources. These resources are environment friendly and not harmful for the environment. So the global demand for solar power, wind power and tidal power is increasing day by day. As the demand is increasing day by day, this is the necessity of time to find the alternative options for biofuel. In the alternative options for biofuel, there is hydrogen energy, air engine etc.

Terminal question

1. **(a) Fill in the blank spaces with appropriate words.**
   A drawback of the production of ....arises because of the pressure on food prices from both the demand and supply side. On the demand side, some uncertainties are leading to higher......................... One uncertainty concerns the rapid expansion of biofuels produced from agricultural feedstock. It can be indicated that the real price ....for maize will be around .... percent by 2020. Substitute grains, like..............., will be influenced by this price......................, given rapid growth in biofuels demand. However, in order that ....stays competitive in the long run, the prices of...................., like maize and sugar, cannot rise faster than real energy prices. The ....that subsequently arises relates to

the price of oil, technical progress in the efficiency of converting ....and ....and the size of government subsidizes

2. **(a) Discuss the conflict with biofuel.**

   (b) What are the advantages of biofuel?

3. **(a) Describe the alternative options of biofuel.**

   (b) Discuss the disadvantages of biofuel.

4. **(a)Explain the Global bio-energy partnership.**
   (b)What do you understand by biofuel?

   (c) Discuss the techniques to get the biofuel from waste material.

5. **(a) Biofuel is the example of non conventional fuel (Yes/No)**

   (b) Second-generation biofuels are made from................

   (c) Which country targeted 3% of energy from plant-based fuels by 2025?

6. **(a) Describe the repercussion of biofuel.**

   (b) Give a note on air engine

Answers

1 (a) biofuels, food prices, increase, 40, wheat increase, biofuel, feedstock, uncertainty, agricultural feedstock, biomass

2 (a) See section 13.2

(b) See section 13.3.1

3 (a) See section 13.5

(b) See section 13.3.2

4 (a) See section 13.4 (g)

(b) See section 13.1

5 (a) Yes

(b) non-food feed stocks

(c) Indonesia

6 (a) See section 13.1

(b) See section 13.5.2

UNIT 14: The future energy: Hydrogen Economy, Fuel cells and

Unit Structure

14.0 Learning Objectives

After studying this unit you will be able to understand:

- What is Future energy?
- What is hydrogen economy
- What is fuel cells
- About hybrid car and is advantages and disadvantages.

14.1. Introduction

As you know demand of energy has continued to increase at global level. Major developing nations acting as the main driving force behind such increases. World energy balance is dominated by fossil fuels. One major issue raised by this is how to change the future energy towards more sustainable and renewable sources of energy.

For many times, fossil fuels (**coal, crude oil and natural gas**) have been the main source of commercial energy for industrial production, heating and transportation. Hydrocarbons, and especially petroleum, have also been used in the pharmaceutical, building and clothing industries, as well as for fertilizers, foodstuffs, plastic-ware and paints. The inclusion of other energy sources, such as nuclear and renewable – wind, solar, geothermal, water and biomass – in the energy matrix has been marginal, because of high costs and underdeveloped technologies. In the case of nuclear power, there are additional safety concerns, including the long-term disposal of radioactive waste. However, recognition of the damaging environmental impact from excessive dependence on fossil fuels, along with growing concerns about the supply of some fossil fuels to meet rising global demand for energy, has brought into focus the need for a cleaner and more diversified energy mix. Hence, renewable energy, including biofuels, has received growing attention. As you know conventional energy resources are leading into pollution. Besides this, these resources are depleting very fast and now whole world is looking for alternative sources of energy. These energy resources may include solar, wind, tidal and geothermal energy resources. In this unit you will learn about the future energy, hydrogen economy, fuel cells and hybrid cars.

14.2. The Future energy

A wide range of alternatives can be deployed to support the market development of renewable energies and increase their share in the world future energy. The future energy is also called renewable energy sources because whole world is looking for alternative sources to fulfill the energy requirements.

14.2.1. Types of future energy sources

The There are various future energy sources which are summarized in figure 1 and also discussed below:

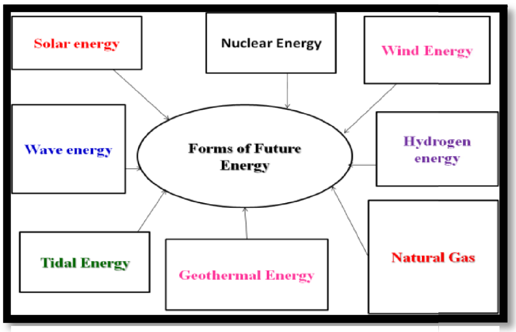


Figure 1 different forms of Future energy

Solar power: This energy resource is completely renewable and could be future energy for the whole world. As you know that solar energy is produced with the help of sun energy. However, this energy resource is weather dependent.

Nuclear Power: Nuclear power is amongst the most abundant form of future energy. It is used by whole world. The main drawback of this energy is that it may leads into catastrophic event.

Wave energy: Water proves itself to be valuable contributor to future energy fuel source with wave energy converters.

Bio-fuels: Bio-fuels make use of animals and plant life to create energy. Biofuels are renewable in cases where plants are used, as the plants can be regrown at regular basis. Therefore, biofuel is also a form of future energy.

Natural Gas: These sources have been in use for many times, but it is through the progression of compression techniques that it is becoming a more viable future energy source.

Geothermal energy: Geothermal power is about extracting energy from the ground of earth. This is also one of the best options of future energy.

Wind energy: Wind energy generation has become increasingly popular in recent times.

Tidal Energy: It is like a hydroelectric method, in which oceanic tides are used to produced energy. This is also form of future energy, however, the energy produced by tidal energy only in the region of sea coasts.

Hydrogen energy: As you know hydrogen is completely clean burning fuel and form of future energy.

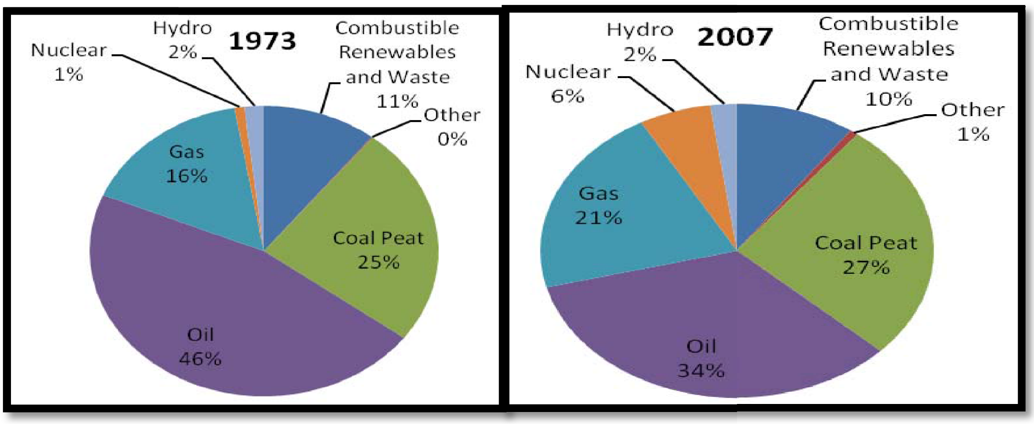


Figure 2 **Total primary energy supply, 1973 and 2007 (*Source*: International Energy**

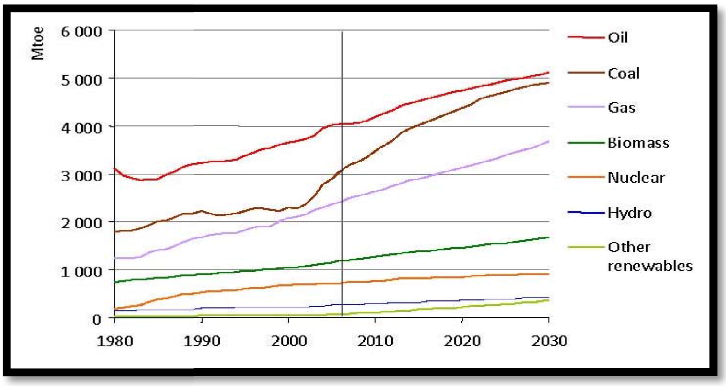


Figure 3: World energy Demand

(S*ource*: Reference scenario, World Energy Outlook 2008).

14.3. Hydrogen Economy

The Hydrogen economy is a term for a new way of delivering and using energy. In brief it describes a future energy scenario where the gas hydrogen will take the place of fossil fuels like oil, natural gas and coal in our energy system. Hydrogen has a high energy density by weight but has a low energy density by volume.

The hydrogen based economy is a long term dream of society and scientist for meeting the increasing demand for energy Hydrogen as fuel in a clean energy system.

The **hydrogen economy** is the use of hydrogen as a fuel, particularly for heating by transportation and using hydrogen energy for long term storage and for long distance transport of low-carbon energy. Hydrogen gas, however, does not occur naturally in convenient reservoirs; it must be produced from other sources. Steam methane reforming is the dominant method for production of H_2 gas. Around 96% of the hydrogen produced annually today is produced by this process.

The purpose of the current production of this hydrogen is as an industrial feedstock, primarily for the production of ammonia, methanol and petroleum refining. Around 96% of the world's hydrogen is produced from natural gas steam reforming.

The production of hydrogen from both the natural gas steam reforming process and the dedicated water electrolysis process are resisted by mandatory efficiency issues. Using fossil based electricity to produce hydrogen from electrolysis, and subsequently using that hydrogen in a fuel cell has a negligible effect on CO_2 emissions (depending on the fuel used for the electricity production).

The production of large amounts of clean electricity (from renewable and nuclear resources) must therefore first be effected, before hydrogen can become an effective energy carrier.

A hydrogen economy was proposed by the University of Michigan to solve some of the negative effects of using hydrocarbon fuels where the carbon is released to the atmosphere (as carbon dioxide, carbon monoxide, unburnt hydrocarbons, etc.).

In the current scenario hydrocarbon economy, transportation is fueled primarily by petroleum and heating natural gas. Burning of hydrocarbon fuels emits CO_2 and other pollutants. The demand for energy is increasing, particularly in China, India, and other developing countries.

The term ***hydrogen economy*** was coined by **John Bockris** in the year **1970** at General Motors Technical Center. The concept was also proposed earlier by geneticist **J.B.S Haldane**. A spike in attention for the concept during the 2000s was repeatedly described as hype by some criticism and exponents of alternative technologies. Interest in the energy carrier restoration in the 2010s, notably by the forming of the Hydrogen Council in **2017**. Several manufacturers released **hydrogen** fuel cell cars commercially, with manufacturers such as Toyota and industry groups in China planning to increase numbers of the cars into the hundreds of thousands over the next decade.

Current hydrogen market

Hydrogen production is a large and growing industry, as of 2004. Globally, 57 million metric tons of hydrogen, equal to about 170 million tons of oil equivalent, were produced in 2004. The growth rate is around 10% per year. Within the United States, 2004 production was about 11 million metric tons, an average power flow of 48GW. (For comparison, the average electric production in 2003 was some 442 GW). As of 2005, the economic value of all hydrogen produced worldwide is about $135 billion per year. There are two primary uses for hydrogen today. About half of it is used in the Haber process to produce ammonia, which is then used directly or indirectly as fertilizer. Because both the world population and the intensive agriculture used to support it are growing, ammonia demand is growing. Ammonia can be used as a safer and easier indirect method of transporting hydrogen.

14.3.1. Production of Hydrogen

_Molecular hydrogen is not available on Earth in convenient natural reservoirs. Most hydrogen in the lithosphere is bonded to oxygen in water. Manufacturing elemental hydrogen does require the consumption of a hydrogen carrier such as a fossil fuel or water. The former carrier consumes the fossil resource and produces carbon dioxide, but often requires no further energy input beyond the fossil fuel. Decomposing water, the latter carrier, requires electrical or heat input, generated from some primary energy source (fossil fuel, nuclear power or a renewable energy). Hydrogen can also be produced by refining the effluent from geothermal sources in the lithosphere. Green hydrogen is a form of hydrogen produced by zero emission renewable energy sources such as electrolysis of water using wind, solar, hydro, wave or tidal power. Hydrogen produced by non-renewable energy sources may be referred to as brown hydrogen. Hydrogen produced as a waste by-product or industrial by-product is sometimes referred to as grey hydrogen.

Current production Technology:

Hydrogen is industrially produced from steam reforming, which uses fossil fuels such as natural gas, oil, or coal. Energy content of the original fuel some of which is being lost as excessive heat during production is more than the energy content of the produced hydrogen car engine leads to emission of CO_2 Similarly steam reforming also leads to CO_2 emission.

A small part (4% in 2006) is produced by electrolysis using electricity and water, consuming approximately 50 kilowatt-hours of electricity per kilogram of hydrogen produced.

Kvaerner-process:

Kvaerner carbon black & hydrogen process (CB&H) is a method, developed in the 1980s by a Norwegian company of the same name, for the production of hydrogen from hydrocarbons (C_nH_m), such as methane, natural gas and biogas.

Electrolysis of water: Electrolysis of water is the decomposition of water into oxygen and hydrogen gas due to the passage of an electric current. The reaction has a standard potential of -1.23 V, meaning it ideally requires a potential difference of 1.23 volts to split water. This technique can be used to make hydrogen gas and breathable oxygen. However, as hydrogen is an important industrial commodity, by the steam reforming process hydrogen is produced.

Behavioural production methods:

Biological production: Fermentative hydrogen production is the conversion of organic substrate to biohydrogen manifested by a diverse group of bacteria using multi enzyme systems involving three steps similar to anaerobic conversion. Dark fermentation reactions are capable of constantly producing hydrogen from organic compounds throughout the day and night because they do not required light energy. For example, photo-fermentation with *Rhodobacter sphaeroides* (SH_2C) can be employed to convert small molecular fatty acids into hydrogen. Electrohydrogenesis is used in microbial fuel cells where hydrogen is produced from organic matter (e.g. from sewage, or solid matter) while 0.2 - 0.8 V is applied.

Photoelectrochemical water splitting: Using electricity produced by photovoltaic systems offers the cleanest way to produce hydrogen. Water is broken into hydrogen and oxygen by electrolysis—a photoelectrochemical cell (PEC) process which is also named artificial photosynthesis. William Ayers at Energy Conversion Devices demonstrated and patented the first multijunction high efficiency photoelectrochemical system for direct splitting of water in 1983. This group demonstrated direct water splitting now referred to as an "artificial leaf" or "wireless solar water splitting" with a low cost thin film amorphous silicon multijunction sheet immersed directly in water. Hydrogen evolved on the front amorphous silicon surface decorated with various catalysts while oxygen evolved on the back metal substrate. A Nafion membrane above the multijunction cell provided a path for ion transport. Their patent also lists a variety of other semiconductor multijunction materials for the direct water splitting in addition to amorphous silicon and silicon germanium alloys. This reaction could just takes place in one step and can improve efficiency if this process is assisted by photocatalysts. Suspended directly in water instead of using photovoltaic and an electrolytic system.

Photoelectrocatalytic production: A method studied by Thomas Nann and his team at the University of East Anglia consists of a gold electrode covered in layers of indium phosphide (InP) nanoparticles. They introduced an iron-sulfur complex into the layered arrangement, which when submerged in water and irradiated with light under a small electric current, produced hydrogen with an efficiency of 60%.

Concentrating solar thermal: Very high temperatures are required to dissociate water into hydrogen and oxygen. A catalyst is required to make the process operate at possible temperatures. Heating the water can be achieved through the use of concentrating solar power. This technology could be readily scaled up to the megawatt range by multiplying the available reactor units and by connecting the plant to heliostat fields (fields of sun-tracking mirrors) of a suitable size.

Thermochemical production: There are more than 352 thermochemical cycles which can be used for water splitting, around a dozen of these cycles such as the iron oxide, cerium (IV) oxide-cerium (III) oxide, zinc zinc-oxide, sulfur-iodine, copper-chlorine and hybrid sulfur cycle are under research and in testing phase to produce hydrogen and oxygen from water and heat without using electricity. These processes can be more efficient than high-temperature electrolysis, typically in the range from 35% - 49% LHV efficiency. Thermochemical production of hydrogen using chemical energy from coal or natural gas is generally not considered, because the direct chemical path is more efficient.

Hydrogen safety: Hydrogen has one of the widest explosive/ignition mix range with air of all the gases with few exceptions such as acetylene, silane, and ethylene oxide. That means that whatever the mix proportion between air and hydrogen, a hydrogen leak will most likely lead to an explosion, not a mere flame, when a flame or spark ignites the mixture. This makes the use of hydrogen particularly dangerous in enclosed areas such as tunnels or underground parking. Pure hydrogen-oxygen flames burn in the ultraviolet color range and are nearly invisible to the naked eye, in order to detect if a hydrogen leak is burring, a flame detector is needed.

There are codes and standards for hydrogen fuel cell vehicles, stationary fuel cell and portable fuel cell applications. There are codes and standards for the safe handling and storage of hydrogen, for example the standard for the installation of stationary fuel cell power systems from the National Fire Protection Association.

One of the measures on the roadmap is to implement higher safety standards like early leak detection with hydrogen sensors. The Canadian Hydrogen Safety Program concluded that hydrogen fueling is as safe as, or safer than, compressed natural gas (CNG) fueling. Hydrogen technologies are safer and comfortable in everyday life with today's fossil fuels.

Captive hydrogen synthetic methane production (SNG synthetic natural gas): In a similar way as with synthetic alcohol production, hydrogen can be used on site to directly (nonbiologically) produce greenhouse-neutral gaseous fuels. Thus, captive-hydrogen-mediated production of greenhouse-neutral methane has been proposed (note that this is the reverse of the present method of acquiring hydrogen from natural methane, but one that does not require ultimate burning and release of fossil fuel carbon). Captive hydrogen (and carbon dioxide from, for example, CCS (Carbon Capture & Storage)) may be used onsite to synthesize methane, using the Sabatier reaction. This is about 60% efficient, and with the round trip reducing to 20 to 36% depending on the method of fuel utilization.

For excess electricity produced by wind, solar photovoltaic, hydro, marine currents and others to produce hydrogen by electrolysis of water and then combine it with CO_2 make methane (natural gas). Hydrogen would firstly be used onsite in fuel cells (CHP) or for transportation due to its greater efficiency of production and then methane created which could then be injected into the existing gas network to generate electricity and heat on demand to overcome low points of renewable energy production. The process described would be able to create hydrogen (which could partly be used directly in fuel cells) and the addition of carbon dioxide CO_2 possibly from BECCS (Bio-Energy with Carbon Capture & Storage via the (Sabatier reaction) to create methane as follows : $CO_2 + 4H_2 \rightarrow CH_4 + 2H_2O$. After combusting methane in CCGT the CO_2 would again be captured, i.e., CCS and used to produce new methane.

14.4. Fuel Cells

A fuel cell is an electrochemical device that produces electricity without combustion by combining hydrogen and oxygen to produce water and heat.

Fuel cell discovered by German Scientist **G H Shoenbein** and first developed by **William Grove.** In 1839, Grove was experimenting on electrolysis (the process by which water is split into hydrogen and oxygen by an electric current), when he observed that combining the same elements could also produce an electric current.

William Grove in 1839, first demonstrated H_2-O_2 fuel cell while working on water electrolyses. In the experiment, water is first electrolyzed into hydrogen and oxygen by a power supply. When the power supply is replaced by an ammeter, a small current is observed, as the flow of electrons from the anode to the cathode. Thus he postulated that if H_2 and O_2 is supplied to Pt electrodes (anode and cathode) dipped in electrolyte solution, electricity is generated . He coined the word Fuel Cell. Francis T. Becon in 1939 used platinum catalyst in a hydrogen-oxygen fuel cell. Developed further with Parsons & Co Ltd, King's College University College of London, University of Cambridge and patented it in 1954 Applied in Apollo Mission in 1965: 3 FCs 463-1463 Watt by NASA for space program.

Working Principle

A fuel cell is a device that uses hydrogen (or hydrogen-rich fuel) and oxygen to create electricity by an electrochemical process. A single fuel cell consists of an electrolyte sandwiched between two thin electrodes (a porous anode and cathode). Hydrogen, or a hydrogen -rich fuel, is fed to the anode where

a catalyst separates hydrogen's negatively charged electrons from positively charged ions (protons) At the cathode, oxygen combines with electrons and, in some cases, with species such as protons or water, resulting in water or hydroxide ions, respectively

The electrons from the anode side of the cell cannot pass through the membrane to the positively charged cathode; they must travel around it via an electrical circuit to reach the other side of the cell. This movement of electrons is an electrical current. The amount of power produced by a fuel cell depends upon several factors, such as fuel cell type, cell size, the temperature at which it operates, and the pressure at which the gases are supplied to the cell. Still, a single fuel cell produces enough electricity for only the smallest applications. Therefore, individual fuel cells are typically combined in series into a fuel cell stack. A typical fuel cell stack may consist of hundreds of fuel cells.

14.4.1. Classification of Fuel Cells

There are various types of fuel cells. On the basis of electrolyte type these may be as Alkaline Fuel cell (AFC), Phosphoric Acid Fuel cell (PAFC), Polymer Electrolytic Membrane Fuel Cell (PEMFC), Solid Polymer Fuel Cell (SPFC) and Proton Exchange Membrane Fuel cell (PEMFC), Molten Carbonate Fuel Cell (MCFC) and Solid Oxide Fuel Cell (SOFC). On the other hand on the basis of types of fuel and oxidant these may be as : Hydrogen (pure)-Oxygen (pure) fuel cell, Hydrogen rich gas-air fuel cell, Ammonia –air fuel cell, Synthesis gas-air fuel cell and Hydro carbon (gas)-air fuel cell.

14.4.2. Advantages and disadvantages of Fuel cells

There are various advantages and disadvantages of fuel cell which are given below:

<u>Advantages of fuel cell:</u>

- More efficient than combustion engines – directly convert chemical energy to electrical energy
- Mechanically ideal – no moving parts , good reliability, long lasting systems
- Clean and silent operation
- Easy independent scaling between power (determined by fuel cell size) and capacity (determined by fuel availability)
- They produce zero or very low emissions, especially Green House Gases (GHGs) depending on the fuel used.
- Have few moving parts and thus require minimal maintenance, reducing life cycle costs of energy production

- Modular in design, offering flexibility in size and efficiencies in manufacturing
- Can be utilized for combined heat and power purposes, further increasing the efficiency of energy production

Disadvantages of Fuel cells:

- Cost – a major issue
- Fuel availability and storage
- Durability under stop-start cycles
- Low volumetric power densities as compared to batteries and combustion engines

14.5. Hybrid Car

The simplest definition of hybrid is that it is anything that combines two or more different elements to produce a given outcome. In the case of motorized vehicles, a hybrid car is one that utilizes two kinds of prompt energy to produce a vehicle that is competitive with the conventional cars already on the market.

Hybrid cars are becoming more popular and more common. Basically, a hybrid car is one that uses two or more engines i.e. an electric motor and a conventional engine (either petrol or diesel). The electric engine powers the car at lower speeds and gas engine powers it at higher speeds. A hybrid car like Toyota Prius and Civic Hybrid not only conserves fuel but also generade less CO2 emissions. Due to lack of knowledge how hybrid vehicle work few people use only gasoline powered vehicle

There are also more government motivated programs that use credits and special discounts to support the purchase and use of hybrid vehicles.

There are cars that use hybrid technologies with propane and natural gas as well. A hybrid car is best defined as a vehicle that has an engine that can switch between a fossil fuel and an alternate fuel source.

The history of hybrid cars stretches back over 100 years. Hybrid cars are defined as any car that runs on two sources of power. The most common hybrid power train combines a gasoline engine with an electric motor. These cars are known as hybrid electric vehicles

(HEVs). While it may seem that hybrids are a recent phenomenon, the technology has been around since the formation of the automobile. In fact, auto manufacturers have been developing and building hybrids since the beginning of the auto industry.

In the Beginning the first hybrid car was built in the year 1899 by engineer Ferdinand Porsche and called the System Lohner-Porsche Mixte, it used a gasoline engine to supply power to an electric motor that drove the car's front wheels. When Henry Ford started the first automobile assembly line in 1904. Ford's ability to produce gasoline-powered cars and offer them at low prices dramatically shrunk the hybrid vehicle market.

In 1910 hybrid car sold poorly due to higher prices and less power than gasoline powered vehicle. In the 1960s, the United States congress introduced legislation that encouraged greater use of electric vehicles in an attempt to reduce air pollution. While the government tried to put more efforts for hybrids, renewed public interest didn't gain momentum until the Arab oil embargo of 1973.

Over the next 25 years, auto manufacturers spent billions of dollars on research and development of hybrid technologies. In spite of this, very few vehicles were produced that could both reduce the world's dependence on oil and compete with gasoline vehicles on price and performance. In the late 1990s, a handful of all-electric vehicles were introduced, the GM EV1 and Toyota RAV-4 EV being two examples.

In 1999, the Honda Insight became the first mass-production HEV released in the United States. The two-door, two-seat Insight may have been first, but it was the Toyota Prius sedan, released in the United States in 2000, that gave hybrid technology the foothold it was looking for.

In this era of ever-increasing environmental awareness, the Prius may be in for some stiff competition. Honda released the second-generation Insight, and Chevrolet introduced of the Volt.

Plug-In Hybrid Introduction:

The next change that consumers should expect to see in the next few years is automakers producing plug-in versions of hybrid vehicles that are able to operate at an extended range in all-electric mode. While consumers have modified current versions of hybrid vehicles to be plug in models, there are currently no commercially available hybrid cars in a plug-in configuration. Expect the first generation of plug in hybrids to have a 40 to 70 mile range in electric-only mode at speeds of up to 50 mile per hour.

NiCad Phase Out

Currently, virtually every hybrid vehicle on the market operates using a Nickel-Cadmium battery pack to store power for its electric motor. While it is a great, durable, proven technology, NiCad has some pretty serious drawbacks. It doesn't charge as well or as fast as other battery types because nickel is very heavy,

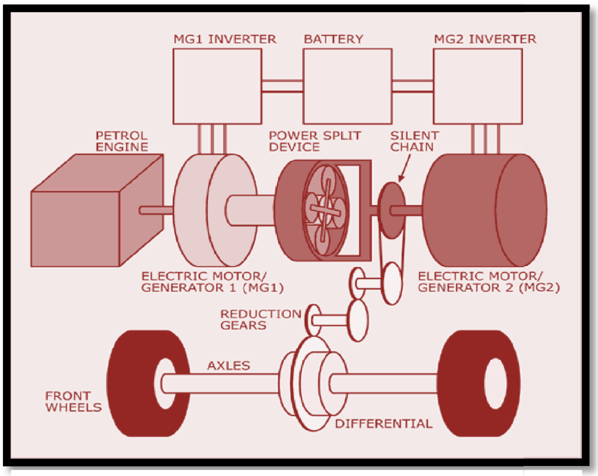


Figure 4: Components of Hybrid car

Diesel-Hybrid Development:

Another significant change to look for is the mating of the positive attributes of the clean diesel power plant with hybrid technology to create a vehicle with even more striking fuel mileage potential. The one-two-punch of clean diesel and hybrid together may make it possible for automakers to stretch towards the 100 mpg mark in coming years.

14.5.1. Advantages and disadvantages of Hybrid Car

Here are some advantages and disadvantages of hybrid car which are summarized in Figure 5 and Figure 6 and also discussed below:

1. <u>Eco-Friendly:</u> One of the biggest advantage of hybrid car over gasoline powered car is that it runs cleaner and has

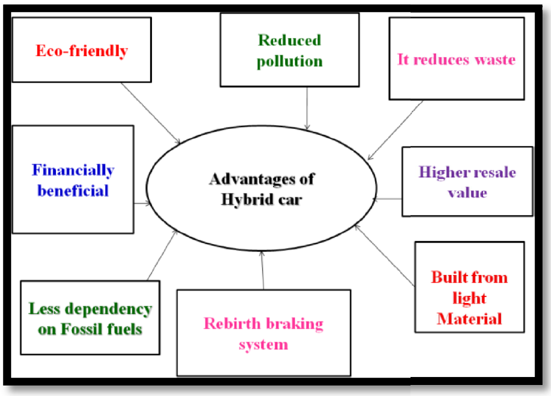


Fig. 5. Advantages of Hybrid Car

better gas mileage which makes it Eco-friendly. A hybrid vehicle runs on twin powered engine (gasoline engine and electric motor) that cuts fuel consumption and conserves energy.

2. Financial Benefits: Hybrid cars are supported by many credits and incentives that help to make them affordable. Lower annual tax bills and relief from overcrowd charges comes in the form of less amount of money spent on the fuel.

3. Less dependence on Fossil Fuels: A Hybrid car is much cleaner and requires less fuel to run which means less emissions and less dependence on fossil fuels. This in turn also helps to reduce the price of gasoline in domestic market.

4. Rebirth Braking System: Each time you apply brake while driving a hybrid vehicle helps you to recharge your battery a little. An internal mechanism kicks in that captures the energy released and uses it to charge the battery which in turn eliminates the amount of time and need for stopping to recharge the battery periodically.

5. Built From Light Materials: Hybrid vehicles are made up of lighter a material which means less energy is required to run. The engine is also smaller and lighter which also saves much energy.

6. Higher Resale Value: With continuous increase in price of gasoline, more and more people are turning towards hybrid cars. The result is that these green vehicles have started commanding higher than average resale values. So, in case you are not satisfied with your vehicle, you can always sell it at a premium price to buyers looking for it.

There are many advantages to owning a hybrid car. The one you will like the best is how it helps you to control your budget as gas prices continue to get higher. The other benefit that is not seen directly is how owning and driving a hybrid car impacts the environment. It reduces the dependence on fossil fuels and lowers your carbon imprint on the environment.

Disadvantages of a Hybrid Car: There are disadvantages of hybrid car which are given below:

1. Less Power: Hybrid cars are twin powered engine. The gasoline engine which is primary source of power is much smaller as compared to what you get in single engine powered car and electric motor is low power. The combined power of both is often less than that of gas powered engine. It is therefore suited for city driving and not for speed and acceleration.

2. Can be Expensive: The biggest drawback of having a hybrid car is that it can burn a hole in your pocket. Hybrid cars are comparatively expensive than a regular petrol car and can cost $5000 to $10000 more than a standard version. However, that extra amount can be offset with lower running cost and tax exemptions.

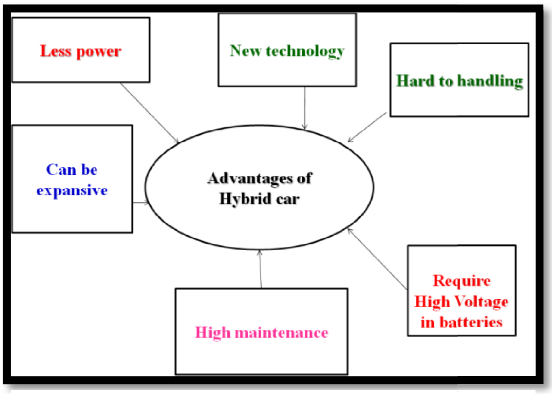


Figure 6 disadvantages of Hybrid Car

3. Poorer Handling: A hybrid car houses a gasoline powered engine, a lighter electric engine and a pack of powerful batteries. This adds weight and eats up the extra space in the car. Extra weight results in fuel inefficiency and if manufacturers cut down weight which has resulted in motor and battery downsizing and less support in the suspension and body.

4. Higher Maintenance Costs: The presence of dual engine, continuous improvement in technology, and higher maintenance cost can make it difficult for mechanics to repair the car. It is also difficult to find a mechanic with such an expertise.

5. Presence of High Voltage in Batteries: In case of an accident, the high voltage present inside the batteries can prove lethal for you. There is a high chance of you getting electrocuted in such cases which can also make the task difficult for rescuers to get other passengers and driver out of the car.

14.5.2. Top ten hybrid cars of world

There are most important hybrid cars are available in the market. The list of top ten hybrid cars of world are given below:

1. Hyundai Ioniq Plug in hybrid
2. Toyota Prius
3. Mini Countryman Cooper SEAll4

4. Toyota Prius Plug-in
5. Hyundai Ioniq Hybrid
6. Kia Niro
7. BMW 225xe iPerformance
8. Toyota Prius+
9. Kia Optima PHEV
10. Ford Mondeo Hybrid

14.6. Summary

In this unit we have discussed future energy, hydrogen economy, fuel cells and hybrid cars. So far you have learnt that:

- ***For many times, fossil fuels (coal, crude oil and natural gas) have been the main source of commercial energy for industrial production, heating and transportation. Hydrocarbons, and especially petroleum, have also been used in the pharmaceutical, building and clothing industries, as well as for fertilizers, foodstuffs, plastic-ware and paints.***
- ***A wide range of alternatives can be deployed to support the market development of renewable energies and increase their share in the world future energy.***
- ***The future energy is also called renewable energy sources because whole world is looking for alternative sources of energy to fulfill the energy requirements.***
- ***There are various future energy sources such as Solar power, Nuclear Power, Wave energy, Biofuels, Natural Gas, Geothermal energy, Wind energy, Tidal Energy, Hydrogen energy.***
- ***The Hydrogen economy is a term for a new way of delivering and using energy. In brief it describes a future energy scenario where the gas hydrogen will take the place of fossil fuels like oil, natural gas and coal in our energy system.***

- ***The hydrogen economy is the use of hydrogen as a fuel, particularly for heating and transportation and using hydrogen energy for long term storage and for long distance transport of low-carbon energy.***
- ***The term hydrogen economy was coined by John Bockris in the year 1970 at General Motors Technical Center. The concept was also proposed earlier by geneticist J,B.S Haldane.***
- ***Hydrogen production is a large and growing industry, as of 2004. Globally, some 57 million metric tons of hydrogen, equal to about 170 million tons of oil equivalent, were produced in 2004. The growth rate is around 10% per year. Within the United States, 2004 production was about 11 million metric tons (Mt), an average power flow of 48GW. (For comparison, the average electric production in 2003 was some 442 GW.)***
- ***A fuel cell is an electrochemical device that produces electricity without combustion by combining hydrogen and oxygen to produce water and heat.***
- ***Fuel cell discovered German Scientist G H Shoenbein and first developed by William Grove. In 1839, Grove was experimenting on electrolysis (the process by which water is split into hydrogen and oxygen by an electric current), when he observed that combining the same elements could also produce an electric current.***
- ***William Grove in 1839, 1st demonstrated H2-O2 fuel cell while working on water electrolyses. In the experiment, water is first electrolysed into hydrogen and oxygen by a power supply. When the power supply is replaced by an ammeter, a small current is observed, as the flow of electrons from the anode to the cathode.***
- ***A fuel cell is a device that uses hydrogen (or hydrogen-rich fuel) and oxygen to create electricity by an electrochemical process. A single fuel cell consists of an electrolyte sandwiched between two thin electrodes (a porous anode and cathode). Hydrogen, or a hydrogen -rich fuel, is fed to the anode where a catalyst separates hydrogen's negatively charged electrons from***

positively charged ions (protons) At the cathode, oxygen combines with electrons and, in some cases, with species such as protons or water, resulting in water or hydroxide ions, respectively.

- ***There are various types of fuel cells such as : Based on the type of Electrolyte these may be Alkaline Fuel cell (AFC), Phosphoric Acid Fuel cell (PAFC), Polymer Electrolytic Membrane Fuel Cell (PEMFC) Solid Polymer Fuel Cell (SPFC) and Proton Exchange Membrane Fuel cell (PEMFC), Molten Carbonate Fuel Cell (MCFC) and Solid Oxide Fuel Cell (SOFC).***
- ***Based on Types of Fuel and oxidant fuel cell may as Hydrogen (pure)-Oxygen (pure) fuel cell, Hydrogen rich gas-air fuel cell, Ammonia –air fuel cell, Synthesis gas-air fuel cell, Hydro carbon (gas)-air fuel cell***
- ***The advantages of fuel cell are: it is more efficient than combustion engines, clean and silent operation, easy independent scaling between power (determined by fuel cell size) and capacity (determined by fuel availability) , they produce zero or very low emissions, especially Green House Gases (GHGs) depending on the fuel used., Have few moving parts and thus require minimal, maintenance, reducing life cycle costs of energy production, Modular in design, offering flexibility in size and , efficiencies in manufacturing etc.***
- ***There are few disadvantages of Fuel cells such as high cost, fuel availability and storage, durability under stop-start cycles and low volumetric power densities as compared to batteries and combustion engines***
- ***Hybrid cars are becoming more popular and more common. Basically, a hybrid car is one that uses two or more engines i.e. an electric motor and a conventional engine (either petrol or diesel).***
- ***There are some advantages of hybrid car such as : it is Eco-Friendly, Financial Benefits, Less dependence on Fossil Fuels, Rebirth Braking System, Built From Light Materials, Higher Resale Value etc.***

- ***Few disadvantages of a Hybrid Car are: it has less Power, it can be Expensive, poorer Handling, Higher Maintenance Costs, Presence of High Voltage in Batteries***

TERMINAL QUESTIONS

1. **(a) Fill in the blank spaces with appropriate words.**

The term hydrogen………. was coined by ……………. in the year…………at General Motors Technical Center. The concept was also proposed earlier by geneticist……... A spike in attention for the concept during the 2000s was repeatedly described as hype by some criticism and exponents of alternative technologies. Interest in the energy carrier restoration in the 2010s, notably by the forming of the Hydrogen Council in……….. Several manufacturers released ………..fuel cell cars commercially, with manufacturers such as Toyota and industry groups in China planning to increase numbers of the cars into the hundreds of thousands over the next decade.

2. **(a)** What is future enegy?

   (b) What are types of future energy sources? Explain in brief.

3. a) Describe the Hydrogen energy.

   b) Give the method of production of hydrogen energy

4. a) Describe the fuel cells.

5. (a) Discuss principles of fuel cells.

   (b) Give the brief classification fuel cell?

   (c) Describe advantages and disadvantages of fuel cells?

6. **a) Fill the blank spaces with appropriate words.**

   Hydrogen ………is a large and growing industry, as of……….. ……., 57 million metric tons of………, equal to about 170 million tons of ……equivalent, were produced in……. The growth rate is around ………per year. Within the United States, 2004 production was about 11 million metric tons, an average power flow of…….... As of 2005, the economic value of all hydrogen produced worldwide is about …………per year. There are two primary uses for hydrogen today. About half is used in the Haber process to produce ………, which is then used directly or indirectly as ………. Because both the world population and the intensive agriculture used to support it are growing, ammonia demand is growing. Ammonia can be used as a safer and easier indirect method of transporting hydrogen.

(b) Hybrid car has….engine/s (One/two)

c) Who coined the term "Hydrogen economy"

d) Which is example of future energy? (Hydrogen/Hydropower/Coal/Petroleum)

e) What do you understand by hybrid? Give the list of top hybrid cars of world.

7. (a) Describe the Hybrid Cars. Explain how it works

(b)Explain advantages of hybrid cars.

(c) Give the disadvantages of hybrid cars.

ANSWERS

1 (a) economy, John Bockris , 1970, J,B.S Haldane, 2017, hydrogen

2 (a) see section 14.2

(b) See section 14.2.1

3 (a) See section 14.3

(b) See section 14.3.1

4 (a) See section 14.4

5 (a) See the section 14.4 under heading working principle.

(b) See the section 14.4.1

(c) See section 14.4.2

6 (a) production, 2004, Globally, hydrogen, oil, 2004, 10%, 48GW, $135 billion, ammonia, fertilizer

(b) Yes

(c) No

(d) Two

(e) See the section 14.5 and 14.5.2

7 (a) See the section 14.5.

(b) See the section 14.5.1 under heading advantages of hybrid car including fig-5

(c) See the section 14.5.1 under heading disadvantages of hybrid car including fig-6