V Skills

Skills for a secure future

Certified Clean Energy Professional
Sample Material

V-Skills Certifications

A Government of India
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V-Skills

Skills for a secure future

1. INTRODUCTION

1.1. Energy Basics and Parameters

Energy is a property of objects which can be transferred to other objects or converted into different forms, but cannot be created or destroyed. The ability of a system to perform work is a common description.

In SI units, energy is measured in joules, the energy transferred to an object by the mechanical work of moving it 1 metre against a force of 1 newton.

Energy Development

Energy development is a field of endeavor focused on making available sufficient primary energy sources and secondary energy forms to meet the needs of society. These endeavors encompass those which provide for the production of conventional, alternative and renewable sources of energy, and for the recovery and reuse of energy that would otherwise be wasted. Energy conservation and efficiency measures reduce the impact of energy development, and can have benefits to society with changes in economic cost and with changes in the environmental effects.

Types of Energy

The natural elements of the material world exist in forms that can be converted into usable energy and are resources from which society can obtain energy to produce heat, light, and motion (among the many uses). According to their nature, the power plants can be classified into:

- ✓ Primary : They are found in nature: wind, water, solar, wood, coal, oil, nuclear.
- ✓ Secondary : Are those obtained from primary energy sources: electricity, gas.

Classified according to the energy reserves of the energy source used and the regeneration capacity with:

- ✓ renewable: When the energy source used is freely regenerated in a short period and there are practically limitless reserves; An example is the solar energy that is the source of energy from the sun, or the wind used as an energy resource.
- ✓ nonrenewable: They are coming from energy limited sources on Earth in quantity and, therefore, are exhaustible. The non-renewable energy sources include, fossil source like petroleum, natural gas, coal or original mineral/chemical like uranium, shale gas.

Characteristics of Energy

- ✓ Energy can be transferred from one object to another.
- ✓ Energy comes in many different forms, which can generally be divided into Potential or Kinetic energy.
- ✓ Energy can be converted from any one of these forms into any other, and vice versa.
- ✓ Energy is never created or destroyed - this is called the First Law of Thermodynamics
- ✓ Energy is capacity to do work

Energy Parameters

Energy Elasticity - Energy elasticity is a term used with reference to the energy intensity of Gross Domestic Product. It is "the percentage change in energy consumption to achieve one per cent change in national GDP".

This term has been used when describing sustainable growth in the developing world, while being aware of the need to maintain the security of energy supply and constrain the emission of additional greenhouse gases. Energy elasticity is a top-line measure, as the commercial energy sources used by the country in question are normally further itemised as fossil, renewable, etc.

For example, India's national Integrated Energy Policy of 2005 noted current elasticity at 0.80, while planning for 7-8% GDP growth. It expected to be able to reduce this to 0.75 from 2011 and to 0.67 from 2021-22. By 2007, India's Ambassador was able to inform the United Nations Security Council that its GDP was growing by 8%, with only 3.7% growth in its total primary energy consumption, suggesting it had effectively de-linked energy consumption from economic growth.

China has shown the opposite relationship, as, after 2000, it has consumed proportionately more energy to achieve its high double-digit growth rate. Although there are problems with the quality of the estimates of both GDP and energy consumption, by 2003-4 observers placed Chinese energy elasticity at approximately 1.5. For every one percent increase in GDP, energy demand grew by 1.5 percent. Much of this extra demand has been sourced internationally from fossil fuels, such as coal and petroleum.

Energy Intensity - Energy intensity is a measure of the energy efficiency of a nation's economy. It is calculated as units of energy per unit of GDP.

- ✓ High energy intensities indicate a high price or cost of converting energy into GDP.
- ✓ Low energy intensity indicates a lower price or cost of converting energy into GDP.

Energy Intensity as defined here is not to be confused with Energy Use Intensity (EUI), a measure of building energy use per unit area.

1.2. Energy Resources

Environmental resources-atmosphere, water, forest, land are natural resources which posses two distinguishing features as compared to other natural resources. They are regenerative in the sense that they are not depleted if we do not use them beyond their natural regenerative levels. The atmosphere and water resources can take some pollution loads without being adversely affected. These environmental resources provide public goods and private goods and services. Public goods have two distinguishing properties as compared to private goods i.e. they are non rival and non exclusive. So private markets are inefficient in allocating public goods as it is difficult or rather, nearly impossible to use market based price systems

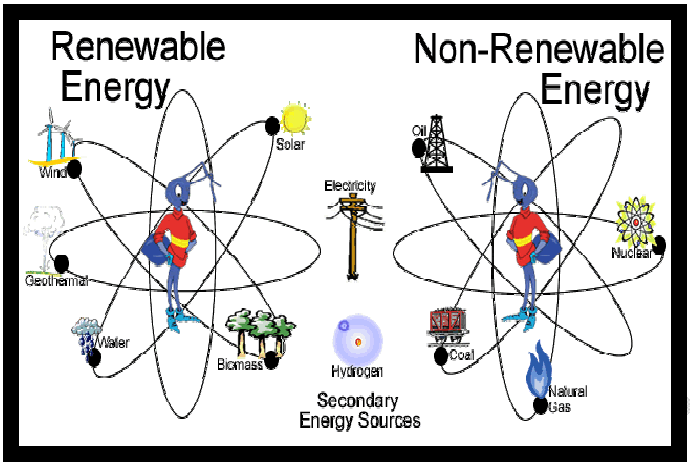
Environmental goods have three other major properties-(a) they are irreversible i.e. the decision to use an environmental resource is irreversible. Once used, we will have to wait for the natural regenerative process, which can occur in an economic or in a geological time frame. (b)uncertainty: there is always uncertainty about the outcome of using an environmental resource .For instance, during the green revolution in India in the 1960's,several high yielding varieties of seeds were introduced .Technological advancements also led to the introduction of fertilizers and pesticides which improved the harvest .However, this supposedly breakthrough improvement was short lived.

Soon, excessive use of subsidized fertilizers led to the soil pollution, lowering of the water table and eventually a massive decline in agricultural harvests. This could not have been prophesied, using any technique, and therefore provides testament to the fact that the outcome of using environmental resources is always uncertain.(c) Uniqueness-some environmental assets are unique in the sense, that they have some existence value. In other words people will be willing to donate some portion of their income for their preservation .For instance, even a person who doesn't live in Africa may donate for conservation of an African rainforest. Environmental conservationists in India may debate or discuss ways and means to protect blue whales and prevent their imminent extinction.

Human Society was powered solely by biomass till a few centuries ago that is, by biological material from the living or recently dead organisms .For instance, our muscles (powered by energy from the food we eat) or fire from burning wood .A living organism maintains its internal order and the entropy level of it's internal system by trapping matter and energy drawn from the outside environment to continuously replace the dead tissues with the new. While an organism secures nutrients to construct and maintain its physical structure, it requires energy to run its basic life processes. Without continuous input of energy, an organic system will stop functioning and the organism will move along a positive entropy gradient until it dies.

Energy can be described as the ability to do work, which can be used to move an object physically against an opposing force over some distance. Energy can also be described as stored work. For example, if a piece of stone has been moved away from the centre of the earth ,work has been done against the gravity of the earth which is equal to the force applied to the stone and multiplied by the distance moved. The stone has acquired potential energy which is converted into kinetic energy (energy of motion) when the stone falls down. In the strict physical sense, mechanical work always involves movement of one body relative to another. Similarly fossil fuel, either coal or hydrocarbons, is a chemical energy resource which under certain conditions can be converted to heat energy (for example fossil fuel burnt to raise steam from water in a boiler).Heat Energy can be transformed into mechanical energy in kinetic form with the help of a mechanical device (for example steam is used to drive a piston which in turn pushes an object and drives a wheel resulting in the movement of an object over a certain distance).

There are nine major types of energy resources. They fall into two categories: nonrenewable and renewable. Nonrenewable energy resources, like coal, nuclear, oil, and natural gas, are accessible in limited supplies. This is usually due to the long time it takes for them to be replenished (a geological time frame, perhaps thousands and thousands of years). Renewable resources are replenished naturally and over relatively short periods of time. The five major renewable energy resources are solar, wind, water (hydro), biomass, and geothermal.



1.3. Conventional and Non Conventional Sources

Conventional: Energy that has been used from ancient times is known as conventional energy. Coal, natural gas, oil, and firewood are examples of conventional energy sources. (or usual) sources of energy (electricity) are coal, oil, wood, peat, uranium. They should be used with caution, as their regeneration could take millions of years. In this sense, it is a universally acknowledged truth that all non renewable forms of energy are conventional but all conventional forms of energy are not necessarily non renewable.

Non-conventional (or unusual) sources of energy include:

- ✓ Solar power
- ✓ Hydro-electric power (dams in rivers)
- ✓ Wind power
- ✓ Tidal power
- ✓ Ocean wave power
- ✓ Geothermal power (heat from deep under the ground)
- ✓ Ocean thermal power (the difference in heat between shallow and deep water)
- ✓ Biomass (burning of vegetation to stop it producing methane)
- ✓ Biofuel (producing ethanol (petroleum) from plants

Differences between conventional and non-conventional energy forms

Conventional Source	Non-Conventional Source
It refers to traditional sources of energy like charcoal, firewood, coal, petroleum, etc	Non-Conventional sources of energy are recently developed sources of energy like from sun, wind, water, tides, geothermal, etc.
These sources of energy are non-renewable	These sources of energy are renewable
Generation of energy is expensive	Initial cost of generation of energy is high but cheaper in the long run.
They cause large scale pollution	They are eco friendly sources of energy.

1.4. Non Renewable Energy Sources

Over 85% of the energy used in the world is non renewable. Most developed nations rely on non-renewable energy sources such as fossil fuels (coal and oil) and nuclear power to meet the requirements of the citizens, in particular and the nation, in general. These sources are called non-renewable because they cannot be renewed or regenerated quickly enough to keep pace with their use.

Industrialized societies depend on non-renewable energy sources: Fossil fuels are the most commonly used types of non-renewable energy. They were formed when incompletely decomposed plant and animal matter was buried in the earth's crust and transformed into carbon-rich material that is useable as fuel. This process occurred over millions of years i.e. a geological time frame. The three main types of fossil fuels are coal, oil, and natural gas. Two other less-used sources of fossil fuels are oil shales and tar sands.

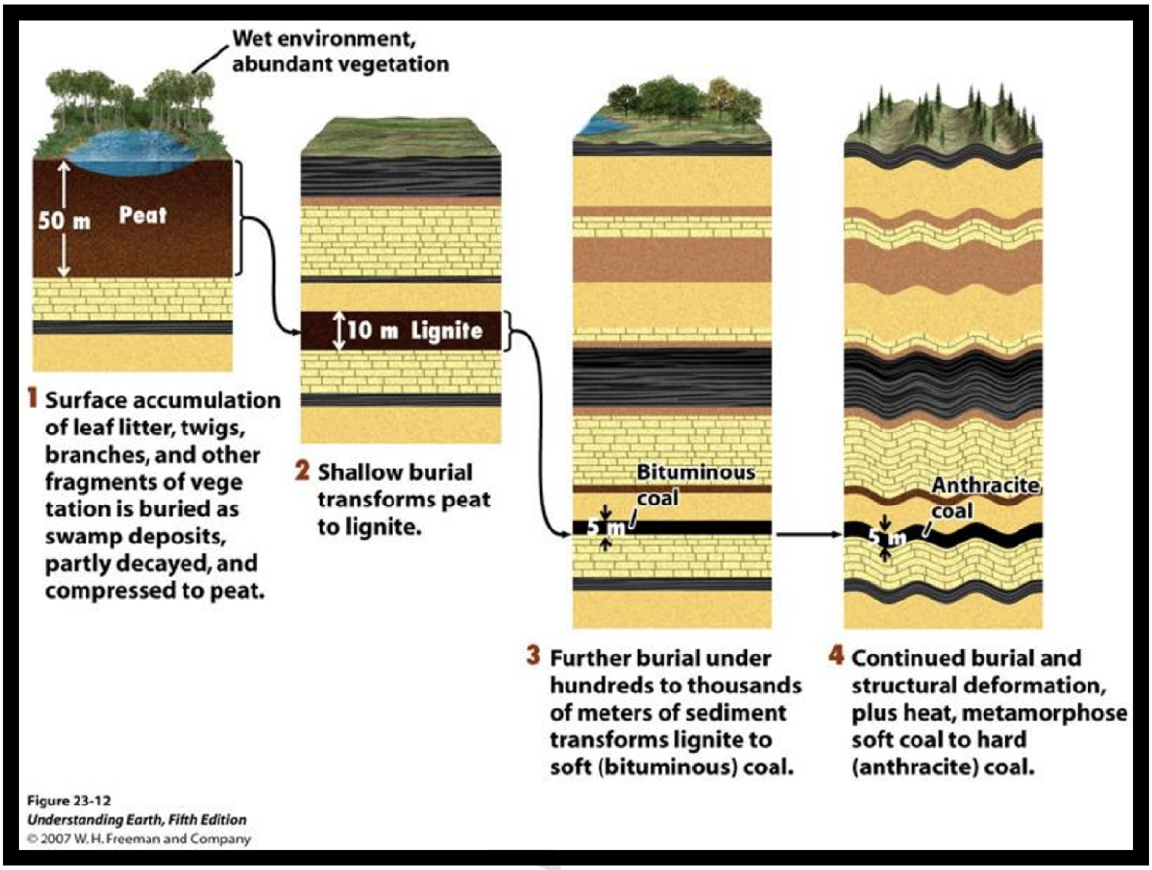
COAL

Coal is the most abundant fossil fuel in the world with an estimated reserve of one trillion metric tons. Most of the world's coal reserves exist in Eastern Europe and Asia, but the United States also has considerable reserves. Coal formed slowly over millions of years from the buried remains of ancient swamp plants. During the formation of coal, carbonaceous matter was first compressed into a spongy material called "peat," which is about 90% water. As the peat became more deeply buried, the increased pressure and temperature turned it into coal.

Different types of coal resulted from differences in the pressure and temperature that prevailed during formation. The softest coal (about 50% carbon), which also has the lowest energy output, is called lignite. Lignite has the highest water content (about 50%) and relatively low amounts of smog-causing sulfur. With increasing temperature and pressure, lignite is transformed into bituminous coal (about 85% carbon and 3% water). Anthracite (almost 100% carbon) is the hardest coal and also produces the greatest energy when burned. Less than 1% of the coal found in the United States is anthracite. Most of the coal found in the United States is bituminous.

Unfortunately, bituminous coal has the highest sulfur content of all the coal types. When the coal is burned, the pollutant sulfur dioxide is released into the atmosphere

The Process of Coal Formation



Coal has many important uses worldwide. The most significant uses of coal are in electricity generation, steel production, cement manufacturing and as a liquid fuel. Around 6.6 billion tonnes of hard coal were used worldwide last year and 1 billion tonnes of brown coal.

Since 2000, global coal consumption has grown faster than any other fuel. The five largest coal users - China, USA, India, Russia and Japan - account for 76% of total global coal use.
Different types of coal have diverse uses. Steam coal - also known as thermal coal - is mainly utilized in power generation. Coking coal - also known as metallurgical coal - is mainly used in steel production.

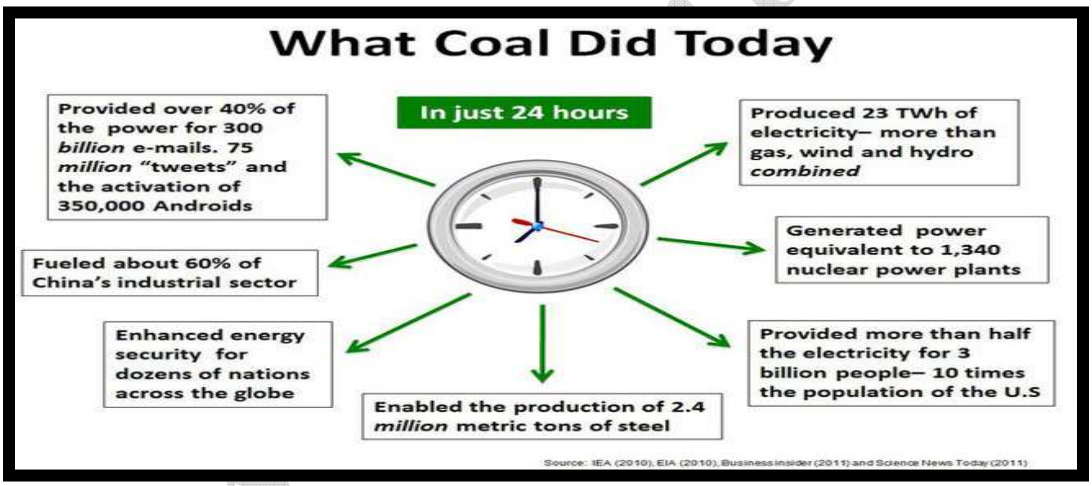
The biggest market for coal is Asia, which currently accounts for over 67% of global coal consumption; although China is liable for a significant proportion of this. Many countries do not have natural energy resources sufficient to cover their energy needs, and therefore need to import energy to help meet their requirements. Japan, Chinese Taipei and Korea, for example, import significant quantities of steam coal for electricity generation and coking coal for steel production. If the exports are less than the imports, this leads to a fall in the net exports and therefore in the volume of trade of these countries. This undoubtedly will have a detrimental effect on the coal industry of these economies. If, however, the volume of trade in the other industries is higher, the economies will perform well in the world market.

Other important users of coal include alumina refineries, paper manufacturers, and the chemical and pharmaceutical industries. Several chemical products can be produced from the by-products of coal. Refined coal tar is used in the manufacture of chemicals, such as creosote oil, naphthalene, phenol, and benzene. Ammonia gas recovered from coke ovens is used to manufacture ammonia salts, nitric acid and agricultural fertilisers.

Thousands of different products have coal or coal by-products as components: soap, aspirins, solvents, dyes, plastics and fibres, such as rayon and nylon. Coal is also an indispensable component in the production of specialist products:

- ✓ **Activated carbon:** used in filters for water and air purification and in kidney dialysis machines.
- ✓ **Carbon fibre:** an extremely strong but light weight reinforcement material used in construction, mountain bikes and tennis rackets.
- ✓ **Silicon metal:** used to produce silicones and silanes, which are in turn used to make lubricants, water repellents, resins, cosmetics, hair shampoos and toothpastes.

This insinuates that, in the absence of coals, the performance and growth of innumerable economies in the world would have been considerably lower.



Coal Electricity Generation

A coal power station turns the chemical energy in coal into electrical energy that can be used in homes and businesses.

First the coal (1) is ground to a fine powder and blown into the boiler (2), where it is burned, converting its chemical energy into heat energy. Grinding the coal into powder increases its surface area, which helps it to burn faster and hotter, producing as much heat and as little waste as possible.

As well as heat, burning coal produces ash and exhaust gases. The ash falls to the bottom of the boiler and is removed by the ash systems (3). It is usually then sold to the building industry and used as an ingredient in various building materials, like concrete.

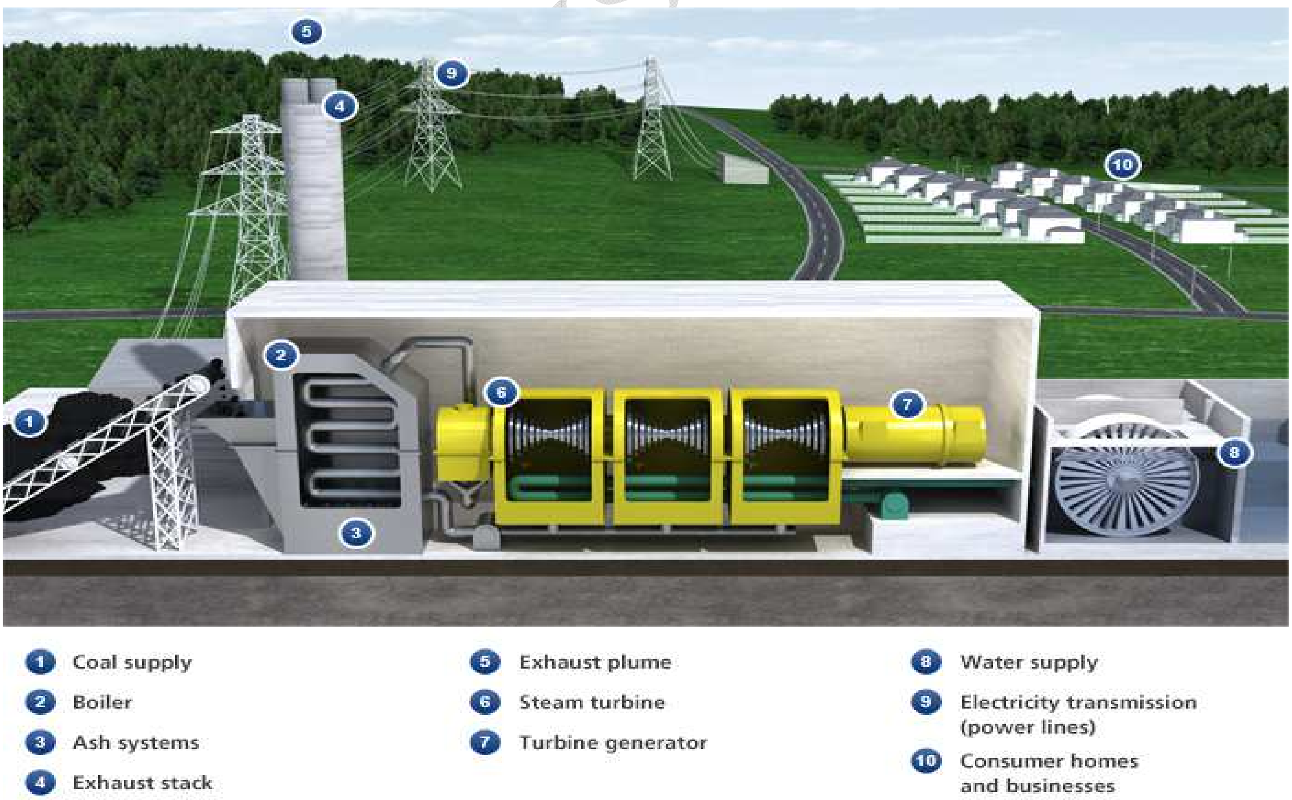
The gases enter the exhaust stack (4), which contains equipment that filters out any dust and ash, before venting into the atmosphere. The exhaust stacks of coal power stations are built tall so that the exhaust plume (5) can disperse before it touches the ground. This ensures that it does not affect the quality of the air around the station.

Burning the coal heats water in pipes coiled around the boiler, turning it into steam. The hot steam expands in the pipes, so when it emerges it is under high pressure. The pressure drives the steam over the blades of the steam turbine (6), causing it to spin, converting the heat energy released in the boiler into mechanical energy.

A shaft connects the steam turbine to the turbine generator (7), so when the turbine spins, so does the generator. The generator uses an electromagnetic field to convert this mechanical energy into electrical energy.

After passing through the turbine, the steam comes into contact with pipes full of cold water. In coastal stations this water is pumped straight from the sea (8). The cold pipes cool the steam so that it condenses back into water. It is then piped back to the boiler, where it can be heated up again, turn into steam again, and keep the turbine turning.

Finally, a transformer converts the electrical energy from the generator to a high voltage. The national grid uses high voltages to transmit electricity efficiently through the power lines (9) to the homes and businesses that need it (10). Here, other transformers reduce the voltage back down to a usable level.

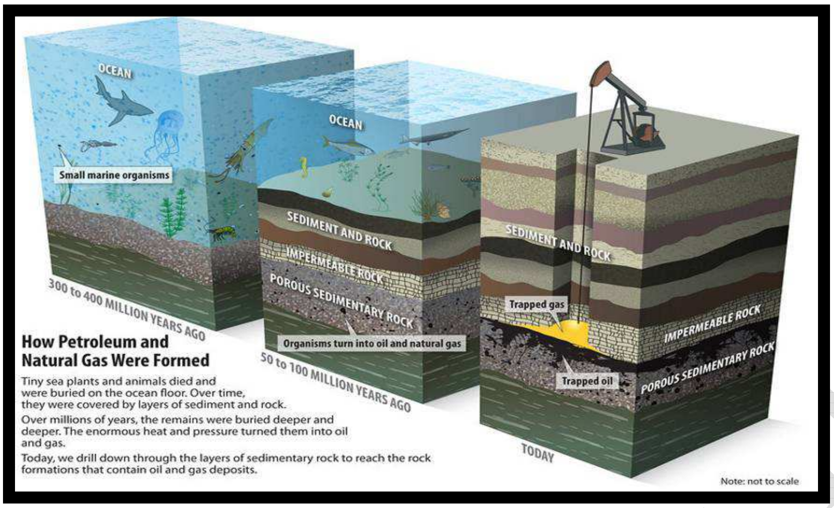


OIL

Crude oil or liquid petroleum, is a fossil fuel that is refined into many different energy products (e.g., gasoline, diesel fuel, jet fuel, heating oil). Oil forms underground in rock such as shale, which is rich in organic materials. After the oil forms, it moves upwards into porous reservoir rock such as sandstone or limestone, where it is trapped by an overlying impermeable cap rock. Wells are drilled into these oil reservoirs to remove the gas and oil. Over 70 percent of oil fields are found near tectonic plate boundaries, because the conditions there are conducive to oil formation.

Oil recovery may or may not have several stages. The primary stage involves pumping oil from reservoirs under the normal reservoir pressure. About 25 percent of the oil in a reservoir can be removed during this stage. The secondary recovery stage involves injecting hot water into the reservoir around the well. This water forces the remaining oil toward the area of the well from which it can be recovered. Sometimes a tertiary method of recovery is used in order to remove as much oil as possible. This involves pumping steam, carbon dioxide gas or nitrogen gas into the reservoir to force the remaining oil toward the well. Tertiary recovery is very expensive and can cost up to half of the value of oil removed. Economists would conduct a cost benefit analysis before this stage to ascertain whether the aggregate benefits of this tertiary recovery are more than the costs involved. Aggregate benefits imply the benefits to society. Carbon dioxide used in this method remains sequestered in the deep reservoir, thus mitigating its potential greenhouse effect on the atmosphere. The refining process required to convert crude oil into useable hydrocarbon compounds involves boiling the crude and separating the gases in a process known as fractional distillation. Besides its use as a source of energy, oil also provides base material for plastics, provides asphalt for roads and is a source of industrial chemicals. Over 50 percent of the world's oil is found in the Middle East; ample additional reserves occur in North America. Most known oil reserves are already being exploited, and oil is being used at a rate that exceeds the rate of discovery of new sources. If the consumption rate continues to increase and no significant new sources are found, oil supplies may be exhausted in another 30 years or so. This is a matter of grave concern indeed. Despite its limited supply, oil is a relatively inexpensive fuel source. This is a surprising occurance, keeping the laws of Economics in mind. A plausible explanation could be that oil is a necessary good with an inelastic supply curve. Oil is a preferred fuel source over coal.

An equivalent amount of oil produces more kilowatts of energy than coal. It also burns cleaner, producing about 50 percent less sulfur dioxide. Environmental problems, also known as “economic bads” or “externalities” are an undeniable part of exploiting any natural resource. If the quantity of these externalities is more than the assimilative capacity of the environment, it will result in pollution/degradation of resources. This, in turn, will have adverse and severe implications for the health of all living beings and the well being of the nation . The burning of oil releases atmospheric pollutants such as sulfur dioxide, nitrogen oxides, carbon dioxide and carbon monoxide. These gases are smog-precursors that pollute the air and greenhouse gases that contribute to global warming. Another environmental issue associated with the use of oil is the impact of oil drilling. Substantial oil reserves lie under the ocean. Oil spill accidents involving drilling platforms kill marine organisms and birds. Some reserves such as those in northern Alaska occur in wilderness areas. The building of roads, structures and pipelines to support oil recovery operations can severely impact the wildlife in those natural areas.



Natural Gas

Natural gas production is often a by-product of oil recovery, as the two commonly share underground reservoirs. Natural gas is a mixture of gases, the most common being methane (CH_4). It also contains some ethane (C_2H_5), propane (C_3H_8), and butane (C_4H_{10}). Natural gas is usually not contaminated with sulfur and is therefore the cleanest burning fossil fuel. After recovery, propane and butane are removed from the natural gas and made into liquefied petroleum gas (LPG). LPG is shipped in special pressurized tanks as a fuel source for areas not directly served by natural gas pipelines (e.g., rural communities). The remaining natural gas is further refined to remove impurities and water vapor, and then transported in pressurized pipelines. The United States has over 300,000 miles of natural gas pipelines. Natural gas is highly flammable and is odorless. The characteristic smell associated with natural gas is actually that of minute quantities of a smelly sulfur compound (ethyl mercaptan) which is added during refining to warn consumers of gas leaks. The use of natural gas is growing rapidly. Besides being a clean burning fuel source, natural gas is easy and inexpensive to transport once pipelines are in place. In developed countries, natural gas is used primarily for heating, cooking, and powering vehicles. It is also used in a process for making ammonia fertilizer. The current estimate of natural gas reserves is about 100 million metric tons. At current usage levels, this supply will last an estimated 100 years. Most of the world's natural gas reserves are found in Eastern Europe and the Middle East.

Oil Shale and Tar Sands

Oil shale and tar sands are the least utilized fossil fuel sources. Oil shale is sedimentary rock with very fine pores that contain kerogen, a carbon-based, waxy substance. If shale is heated to 490º C, the kerogen vaporizes and can then be condensed as shale oil, a thick viscous liquid. This shale oil is generally further refined into usable oil products. Production of shale oil requires large amounts of energy for mining and processing the shale. Indeed about a half barrel of oil is required to extract every barrel of shale oil. Oil shale is plentiful, with estimated reserves totaling 3 trillion barrels of recoverable shale oil. These reserves alone could satisfy the world's oil needs for about 100 years. Environmental problems associated with oil shale recovery include: large amounts of water needed for processing, disposal of toxic waste water, and disruption of large areas of surface lands. Tar sand is a type of sedimentary rock that is impregnated with a very thick crude oil. This thick crude does not flow easily and thus normal oil recovery methods cannot be used to mine it.

If tar sands are near the surface, they can be mined directly. In order to extract the oil from deep-seated tar sands, however, steam must be injected into the reservoir to make the oil flow better and push it toward the recovery well. The energy cost for producing a barrel of tar sand is similar to that for oil shale. The largest tar-sand deposit in the world is in Canada and contains enough material (about 500 billion barrels) to supply the world with oil for about 15 years. However, because of environmental concerns and high production costs these tar sand fields are not being fully utilized.

Nuclear Power

In most electric power plants, water is heated and converted into steam, which drives a turbine-generator to produce electricity. Fossil-fueled power plants produce heat by burning coal, oil, or natural gas. In a nuclear power plant, the fission of uranium atoms in the reactor provides the heat to produce steam for generating electricity. Several commercial reactor designs are currently in use in the United States. The most widely used design consists of a heavy steel pressure vessel surrounding a reactor core. The reactor core contains the uranium fuel, which is formed into cylindrical ceramic pellets and sealed in long metal tubes called fuel rods.

Thousands of fuel rods form the reactor core. Heat is produced in a nuclear reactor when neutrons strike uranium atoms, causing them to split in a continuous chain reaction. Control rods, which are made of a material such as boron that absorbs neutrons, are placed among the fuel assemblies. When the neutron-absorbing control rods are pulled out of the core, more neutrons become available for fission and the chain reaction speeds up, producing more heat. When they are inserted into the core, fewer neutrons are available for fission, and the chain reaction slows or stops, reducing the heat generated. Heat is removed from the reactor core area by water flowing through it in a closed pressurized loop. The heat is transferred to a second water loop through a heat exchanger. The water also serves to slow down, or "moderate" the neutrons which is necessary for sustaining the fission reactions. The second loop is kept at a lower pressure, allowing the water to boil and create steam, which is used to power the turbine-generator and produce electricity.

Originally, nuclear energy was expected to be a clean and cheap source of energy. Nuclear fission does not produce atmospheric pollution or greenhouse gases and it proponents expected that nuclear energy would be cheaper and last longer than fossil fuels. Unfortunately, because of construction cost overruns, poor management, and numerous regulations, nuclear power ended up being much more expensive than predicted. The nuclear accidents at Three Mile Island in Pennsylvania and the Chernobyl Nuclear Plant in the Ukraine raised concerns about the safety of nuclear power. Furthermore, the problem of safely disposing spent nuclear fuel remains unresolved. The United States has not built a new nuclear facility in over twenty years, but with continued energy crises across the country that situation may change.

Nuclear power is the use of nuclear reactors to release nuclear energy, and thereby produce electricity. The term includes nuclear fission, nuclear decay and nuclear fusion. Presently, the nuclear fission of elements in the actinide series of the periodic table produce the vast majority of nuclear energy in the direct service of humankind, with nuclear decay processes, primarily in the form of geothermal energy, and radioisotope thermoelectric generators, in niche uses making up the rest. Nuclear (fission) power stations, excluding the contribution from naval nuclear fission reactors, provided 13% of the world's electricity in 2012. The share of the world's primary energy supply, which refers to the heat production without the conversion efficiency of about 33 %, was about 5.7%.Its share of the global final energy consumption (actually useful energy, i.e. electric power) is below 2.5 %.

In 2013, the IAEA report that there are 437 operational nuclear power reactors, in 31 countries, although not every reactor is producing electricity. In addition, there are approximately 140 naval vessels using nuclear propulsion in operation, powered by some 180 reactors. As of 2013, attaining a net energy gain from sustained nuclear fusion reactions, excluding natural fusion power sources such as the Sun, remains an ongoing area of international physics and engineering research. More than 60 years after the first attempts, commercial fusion power production remains unlikely before 2050.

There is an ongoing debate about nuclear power. Proponents, such as the World Nuclear Association, the IAEA and Environmentalists for Nuclear Energy contend that nuclear power is a safe, sustainable energy source that reduces carbon emissions. Opponents, such as Greenpeace International and NIRS, contend that nuclear power poses many threats to people and the environment.

Nuclear power plant accidents include the Chernobyl disaster (1986), Fukushima Daiichi nuclear disaster (2011), and the Three Mile Island accident (1979). There have also been some nuclear submarine accidents. In terms of lives lost per unit of energy generated, analysis has determined that nuclear power has caused less fatalities per unit of energy generated than the other major sources of energy generation. Energy production from coal, petroleum, natural gas and hydropower has caused a greater number of fatalities per unit of energy generated due to air pollution and energy accident effects. However, the economic costs of nuclear power accidents are high, and meltdowns can render areas uninhabitable for very long periods. The human costs of evacuations of affected populations and lost livelihoods are also significant.

Along with other sustainable energy sources, nuclear power is a low carbon power generation method of producing electricity, with an analysis of the literature on its total life cycle emission intensity finding that it is similar to other renewable sources in a comparison of greenhouse gas emissions per unit of energy generated. With this translating into, from the beginning of nuclear power station commercialization in the 1970s, having prevented the emission of about 64 billion tonnes of carbon dioxide equivalent, greenhouse gases, gases that would have otherwise resulted from the burning of fossil fuels in thermal power stations.

As of 2012, according to the IAEA, worldwide there were 68 civil nuclear power reactors under construction in 15 countries, approximately 28 of which in the Peoples Republic of China (PRC), with the most recent nuclear power reactor, as of May 2013, to be connected to the electrical grid, occurring on February 17, 2013 in Hongyanhe Nuclear Power Plant in the PRC. In the USA, two new Generation III reactors are under construction at Vogtle. U.S. nuclear industry officials expect five new reactors to enter service by 2020, all at existing plants. In 2013, four aging, uncompetitive, reactors were permanently closed.

Japan's 2011 Fukushima Daiichi nuclear disaster, which occurred in a reactor design from the 1960s, prompted a re-examination of nuclear safety and nuclear energy policy in many countries. Germany decided to close all its reactors by 2022, and Italy has banned nuclear power. Following

Fukushima, in 2011 the International Energy Agency halved its estimate of additional nuclear generating capacity to be built by 2035.

1.5. Renewable Energy Sources

Renewable energy (sources) or RES capture their energy from existing flows of energy, from on-going natural processes, such as sunshine, wind, wave power, flowing water (hydropower), biological processes such as anaerobic digestion, and geothermal heat flow.

The most common definition is that renewable energy is from an energy resource that is replaced by a natural process at a rate that is equal to or faster than the rate at which that resource is being consumed. Renewable energy is a subset of sustainable energy.

Most renewable forms of energy, other than geothermal and tidal power, ultimately derive from solar energy. Energy from biomass derives from plant material produced by photosynthesis using the power of the sun. Wind energy derives from winds, which are generated by the sun's uneven heating of the atmosphere. Hydropower depends on rain which again depends on sunlight's power to evaporate water.

Even fossil fuels derive from solar energy, as fossil fuel originates from plant material. However, while theoretically renewable on a very long time-scale, fossil fuels are exploited at rates that may deplete these resources in the near future, and are therefore not considered renewable.

Renewable energy resources may be used directly, or used to create other more convenient forms of energy. Examples of direct use are solar ovens, geothermal heating, and water- and windmills. Examples of indirect use which require energy harvesting are electricity generation through wind turbines or photovoltaic cells (PV cells), or production of fuels such as biogas from anaerobic digestion or ethanol from biomass.

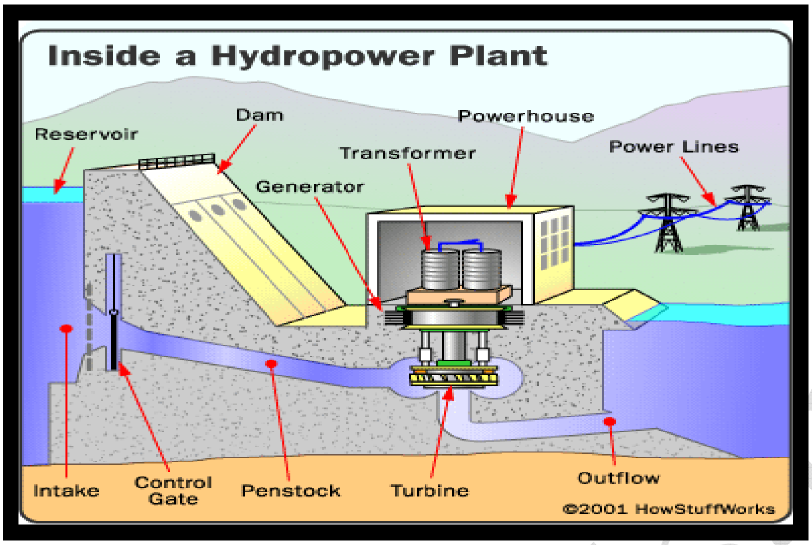
Renewable energy development is concerned with the use of renewable energy sources by humans. Modern interest in renewable energy development is linked to concerns about exhaustion of fossil fuels and environmental, social and political risks of extensive use of fossil fuels and nuclear energy.

Hydroelectric Power

Hydropower plants confine the energy of falling water to generate electricity. A turbine converts the kinetic energy of falling water into mechanical energy. Then a generator converts the mechanical energy from the turbine into electrical energy.

Hydroplants vary in size from "micro-hydros" that power only a few homes to giant dams like Hoover Dam that supply electricity to millions of people, across several regions.

The following diagram adequately depicts how a hydropower plant works:



Most conventional hydroelectric plants include four major components :

- ✓ Dam: Raises the water level of the river to create falling water. Also controls the flow of water. The reservoir that is formed is, in effect, stored energy.
- ✓ Turbine: The force of falling water pushing against the turbine's blades causes the turbine to spin. A water turbine is much like a windmill, except the energy is provided by falling water instead of wind. The turbine converts the kinetic energy of falling water into mechanical energy.
- ✓ Generator: Connected to the turbine by shafts and possibly gears so when the turbine spins it causes the generator to spin also. Converts the mechanical energy from the turbine into electric energy. Generators in hydropower plants work just like the generators in other types of power plants.
- ✓ Transmission lines: Conduct electricity from the hydropower plant to homes and business.

Wind Power

Wind power is produced by using wind generators to harness the kinetic energy of wind. It is gaining worldwide popularity as a large scale energy source, although it still only provides less than one percent of global energy consumption.

Fuel Cells

A fuel cell is a device that generates electricity by a chemical reaction. Every fuel cell has two electrodes, one positive and one negative, called, respectively, the anode and cathode. The reactions that produce electricity take place at the electrodes.

Photo Voltaic Cells

A photovoltaic cell (PV cell) is a specialized semiconductor diode that converts visible light into direct current (DC). Some PV cells can also convert infrared (IR) or ultraviolet (UV) radiation into DC electricity. Photovoltaic cells are an integral part of solar-electric energy systems, which are becoming increasingly important as alternative sources of utility power.

The first PV cells were made of silicon combined, or doped, with other elements to affect the behavior of electrons or holes (electron absences within atoms). Other materials, such as copper indium diselenide (CIS), cadmium telluride (CdTe), and gallium arsenide (GaAs), have been developed for use in PV cells. There are two basic types of semiconductor material, called positive (or P type) and negative (or N type). In a PV cell, flat pieces of these materials are placed together, and the physical boundary between them is called the P-N junction. The device is constructed in such a way that the junction can be exposed to visible light, IR, or UV. When such radiation strikes the P-N junction, a voltage difference is produced between the P type and N type materials. Electrodes connected to the semiconductor layers allow current to be drawn from the device.

Large sets of PV cells can be connected together to form solar modules, arrays, or panels. The use of PV cells and batteries for the generation of usable electrical energy is known as photovoltaics. One of the major advantages of photovoltaics is the fact that it is non-polluting, requiring only real estate (and a reasonably sunny climate) in order to function. Another advantage is the fact that solar energy is unlimited. Once a photovoltaic system has been installed, it can provide energy at essentially no cost for years, and with minimal maintenance.

1.6. India's Power Potential

Though India has a huge renewable energy potential, availability of renewable energy sources is widely dispersed. In some states the potential for renewable energy is insignificant (e.g., Delhi), whereas some states have abundant renewable sources: wind energy is abundant in Gujarat, Karnataka, Maharashtra, Tamil Nadu, and Jammu and Kashmir; solar energy is concentrated in the northwest region of the country—in Gujarat, Rajasthan, Ladakh, Maharashtra, and Madhya Pradesh; and the small hydro potential in the country is concentrated in hilly states of Himachal Pradesh, Uttaranchal, Jammu and Kashmir, Arunachal Pradesh, and Chhattisgarh.

Hydropower: The hydropower installed capacity as of March 31, 2011, was approximately 37,367.4 MW.

The estimated small hydro power potential in India is around 15,000 MW. Of this estimated potential only 16% has been developed so far for power generation. In India, 5415 sites with a capacity of 14,305.47 MW have been identified by Ministry of New and Renewable Energy (MNRE) for the establishment of small hydroelectric projects. The largest numbers of sites have been identified in Arunachal Pradesh with a total capacity of 1,333.04 MW, but the richest state in SHP potential is Himachal Pradesh with 547 sites of total capacity 2,268.41MW.

Wind Energy: India's wind resources have been mapped by the Centre for Wind Energy Technology (CWET). Sites are classified based on wind speeds (higher average wind speeds having higher class numbers). Most of the Indian wind sites are in Class 2 (200–300 W/m2 at 50 MAGL) and some are in Class 3, with relatively few sites in Classes 4 and 5. Despite the relatively low wind regimes by international standards, India has made significant progress in wind based power generation.

The potential areas for generating power through wind mills are in the states of Tamil Nadu, Karnataka, Kerala, Gujarat, Andhra Pradesh, Kerala, Maharashtra, Rajasthan and Madhya Pradesh. As of August 31, 2011 the installed capacity of wind power in India was 14,989.89 MW, mainly spread across Tamil Nadu (6,286.02 MW), Maharashtra (2,400.05 MW), Gujarat (2,337.31 MW), Karnataka (1,773.25 MW), Rajasthan (1,678.62 MW), Madhya Pradesh (275.89 MW), Andhra Pradesh (199.15 MW), Kerala (35.30 MW), and West Bengal (1.1 MW).

During the 2010-11 financial year, India added 2,349.50 MW of wind capacity for a total installed capacity of 14,156.39 MW, which is represented a 19.9% annual growth rate. More recent data showed that India's wind capacity totalled 14,989.89 MW at the end of August, 2011, which represented 70.96% of India's total renewable energy capacity. India's robust domestic market has transformed the Indian wind industry into a significant global player.

Geothermal Energy: The geothermal resources in India have not been exploited commercially for heat or power generation. The geothermal resources, however, have been mapped, and the Geological Survey of India estimates the power generation potential to be in the order of 10,000MW. Most of the current usage of geothermal energy is for direct use, for example bathing and swimming. Dr Chandrasekhar am estimates an installed capacity of 203MW (thermal), with an annual energy use of 1607 TJ/year and a capacity factor of 25%.

Solar Energy: The annual solar radiation over India ranges from 1,200 to 2,300 kWh/m2, with most of the country having radiation greater than 1900 kWh/m2/year, with about 300 clear sunny days. For comparison, in Germany, annual solar radiation ranges from 800 kWh/m2 to 1200 kWh/m2. The area required to meet India's power energy needs (620 billion kWh in 2005) with solar photovoltaic's (at an efficiency of 10%) is about 3,000 km2 (60 km by 50 km) which is 0.1% of the land area of the country. The amount of solar energy produced in India is less than 1% of the total energy demand. The grid-interactive solar power as of December 2010 was merely 10 MW. In 2009, solar power contributed approximately 27 GWh to the national electricity supply.

In India, Cochin International Airport is set to become the first airport in the country to use solar power for running its utility grid system. Vikram Solar has installed 400 solar panels with peak capacity of 100kW at the airport in the state of Kerala and energy production is estimated at 148MWh a year, to be used primarily for the air conditioning facility. The project benefits from a 30% subsidy under the Jawaharlal Nehru National Solar Mission and the airport has invested some INR 6.3 million ($0.12 million), according to officials.

Biomass Energy: Being an agrarian nation, India has considerable potential to use many forms of biomass. The total potential for biomass-based power generation is estimated to be 21,000 MW. Current utilisation amounts to approximately 2,735.2 MW, with various technologies and projects currently in development to increase this. For example, Singapore-based All Green are investing in 10 biomass gasification plants in the country, expected to be completed within the next two years.

Policy Financing and Implementation of Non Renewable energy sources in India

The energy policy of India is largely defined by the country's up-and-coming energy deficit and augmented focus on developing alternative sources of energy, particularly nuclear, solar and wind energy.

The energy consumption in India is the fourth largest after China, USA and Russia. The total primary energy consumption from crude oil (29.45%), natural gas (7.7%), coal (54.5%), nuclear energy (1.26%), hydro electricity (5.0%), wind power, biomass electricity and solar power is 595 Mtoe in the year 2013. In the year 2013, India's net imports are nearly 144.3 million tons of crude oil, 16 Mtoe of LNG and 95 Mtoe coal totaling to 255.3 Mtoe of primary energy which is equal to 42.9% of total primary energy consumption. About 70% of India's electricity generation capacity is from fossil fuels, with coal accounting for 40% of India's total energy consumption followed by crude oil and natural gas at 28% and 6% respectively. India is largely dependent on fossil fuel imports to meet its energy demands — by 2030, India's dependence on energy imports is expected to exceed 53% of the country's total energy consumption. In 2009-10, the country imported 159.26 million tonnes of crude oil which amounts to 80% of its domestic crude oil consumption and 31% of the country's total imports are oil imports. The growth of electricity generation in India has been hindered by domestic coal shortages and as a consequence, India's coal imports for electricity generation increased by 18% in 2010.

Due to rapid economic expansion, India has one of the world's fastest growing energy markets and is expected to be the second-largest contributor to the increase in global energy demand by 2035, accounting for 18% of the rise in global energy consumption. Given India's growing energy demands and limited domestic fossil fuel reserves, the country has ambitious plans to expand its renewable and nuclear power industries. India has the world's fifth largest wind power market and plans to add about 100GW of solar power capacity by 2022.India also envisages to increase the contribution of nuclear power to overall electricity generation capacity from 4.2% to 9% within 25 years. The country has five nuclear reactors under construction (third highest in the world) and plans to construct 18 additional nuclear reactors (second highest in the world) by 2025.

Energy conservation has emerged as a major policy objective, and the Energy Conservation Act 2001, was passed by the Indian Parliament in September 2001, 35.5% of the population still live without access to electricity. This Act requires large energy consumers to adhere to energy consumption norms; new buildings to follow the Energy Conservation Building Code; and appliances to meet energy performance standards and to display energy consumption labels. The Act also created the Bureau of Energy Efficiency to implement the provisions of the Act. In the year 2015, Prime Minister Mr. Modi launched a scheme called Prakash Path urging people to use LED lamps in place of other lamps to drastically cut down lighting power requirement.

India imports nearly 75% of its 4.3 million barrels per day crude oil needs but exports nearly 1.25 million barrels per day of refined petroleum products which is nearly 30% of its total production of refined oil products. India has built surplus world class refining capacity using imported crude oil for exporting refined petroleum products . The net imports of crude oil is lesser by one fourth after accounting exports and imports of refined petroleum products.

During the financial year 2012-13, the production of crude oil is 37.86 million tons and 40,679 million standard cubic meters (nearly 26.85 million tons) natural gas. The net import of crude oil & petroleum products is 146.70 million tons worth of Rs 5611.40 billions. This includes 9.534 million tons of LNG imports worth of Rs. 282.15 billions. Internationally, LNG price (One mmBtu of LNG = 0.1724 barrels of crude oil (boe) = 24.36 cubic meters of natural gas) is fixed below crude oil price in terms of heating value. LNG is slowly gaining its role as direct use fuel in road and marine transport without regasification. In the year 2012-13, India consumed 15.744 million tons petrol and 69.179 million tons diesel which are mainly produced from imported crude oil at huge foreign exchange out go. Use of natural gas for heating, cooking and electricity generation is not economical as more and more locally produced natural gas will be converted in to LNG for use in transport sector to reduce crude oil imports. In addition to the conventional natural gas production, coal gasification, coal bed methane, coal mine methane and Biogas digesters / Renewable natural gas will also become source of LNG forming decentralised base for production of LNG to cater to the widely distributed demand. There is possibility to convert most of the heavy duty vehicles (including diesel driven rail engines) in to LNG fuelled vehicles to reduce diesel consumption drastically with operational cost and least pollution benefits.

The state-owned Oil and Natural Gas Corporation (ONGC) acquired shares in oil fields in countries like Sudan, Syria, Iran, and Nigeria – investments that have led to diplomatic tensions with the United States. Because of political instability in the Middle East and increasing domestic demand for energy, India is keen on decreasing its dependency on OPEC to meet its oil demand, and increasing its energy security. Several Indian oil companies, primarily led by ONGC and Reliance Industries, have started a massive hunt for oil in several regions in India including Rajasthan, Krishna Godavari Basin and north-eastern Himalayas. India is developing an off shore gas field in Mozambique. The proposed Iran-Pakistan-India pipeline is a part of India's plan to meet its increasing energy demand.

India has the world's 4th largest coal reserves. In India, coal is the bulk of primary energy contributor with 54.5% share out of the total 595 Mtoe in the year 2013. India is the third top coal producer in 2013 with 7.6% production share of coal (including lignite) in the world. Top five hard and brown coal producing countries in 2013 (2012) are (million tons): China 3,680 (3,645), United States 893 (922), India 605 (607), Australia 478 (453) and Indonesia 421 (386). However, India ranks fifth in global coal production at 228 mtoe (5.9%) in the year 2013 when its inferior quality coal tonnage is converted in to tons of oil equivalent. Coal-fired power plants account for 59% of India's installed electricity capacity. After electricity production, coal is also used for cement production in substantial quantity. In the year 2013, India imported nearly 95 Mtoe of steam coal and coking coal which is 29% of total consumption to meet the demand in electricity, cement and steel production.

Gasification of coal or lignite produces syngas or coal gas or coke oven gas which is a mixture of hydrogen, carbon monoxide and carbon dioxide gases. Coal gas can be converted in to synthetic natural gas (SNG) by using Fischer–Tropsch process at low pressure and high temperature. Coal gas can also be produced by underground coal gasification where the coal deposits are located deep in the ground or uneconomical to mine the coal. CNG and LNG are emerging as economical alternatives to diesel oil with the escalation in international crude oil prices. Synthetic natural gas production technologies have tremendous scope to meet the transport sector requirements fully using the locally available coal in India. Dankuni coal complex is producing syngas which is piped to the industrial users in Calcutta. Many coal based fertiliser plants which are shut down can also be retrofitted economically to produce SNG as LNG and CNG fetch good price by substituting imports. Recently, Indian government fixed the natural gas price at producer end as 5.61 US$ per mmbtu on net calorific value (NCV) basis which is at par with the estimated SNG price from coal.

Gasification of bio mass yields wood gas or syngas which can be converted in to substitute natural gas by Methanation Nearly 750 million tons of non edible (by cattle) biomass is available annually in India which can be put to higher value addition use and substitute imported crude oil, coal, LNG, urea fertiliser, nuclear fuels, etc. It is estimated that renewable and carbon neutral biomass resources of India can replace present consumption of all fossil fuels when used productively.

Huge quantity of imported coal is being used in pulverised coal fired power stations. Raw biomass can not be used in the pulverised coal mills as they are difficult to grind in to fine powder due to caking property of raw biomass. However biomass can be used after Torrefaction in the pulverised coal mills for replacing imported coal. North west and southern regions can replace imported coal use with torrefied biomass where surplus agriculture/crop residual biomass is available.

The former President of India, Dr. Abdul Kalam, is one of the strong advocaters of Jatropha cultivation for production of bio-diesel. In his recent speech, the Former President said that out of the 6,00,000 km² of waste land that is available in India over 3,00,000 km² is suitable for Jatropha cultivation. Once this plant is grown, it has a useful lifespan of several decades. During its life Jatropha requires very little water when compared to other cash crops. A plan for supplying incentives to encourage the use of Jatropha has been coloured with green stripes.

1.7. Indian Government Authorities

Ministry of Power

The Ministry is responsible for:

- ✓ General Policy in the electricity sector and issues relating to energy policy;
- ✓ Matters relating to hydroelectric (except small/mini/micro hydro projects of and below 25 MW capacities) and thermal power, and the transmission system network;
- ✓ Research, development and technical assistance relating to hydro-electric and thermal power, and the transmission system.
- ✓ Administration of the Electricity Act, 2003, the Damodar Valley Corporation Act, 1948 and the Bhakra Beas Management Board as provided in the Punjab Re-organisation Act, 1966;
- ✓ Matters related to both the Central Electricity Authority and the Central Electricity Regulatory Commission;
- ✓ (a) Rural Electrification, (b) Power Schemes in Union Territories, and issues relating to power supply in the States and Union Territories;
- ✓ Administrative control of Public Sector Undertakings, Statutory and Autonomous Bodies functioning under the Ministry;
- ✓ Other Public Sector Enterprises in energy except projects specifically allotted to any other Ministry or Department;
- ✓ All matters concerning energy conservation and energy efficiency pertaining to the sector.

Ministry of New and Renewable Energy (MNRE, www.mnre.gov.in)

MNRE is the nodal Ministry of the government of India for all matters relating to new and renewable energy and the administrative ministry for policies and programs in this area. The Ministry itself is organised into several divisions dealing with different technologies and applications.

The programme of the ministry is largely implemented through State Nodal Agencies. All major States have set up energy agencies for the non-conventional energy programme.

Ministry of Coal

It is responsible for policies and strategies with respect to exploring and developing coal reserves, sanctioning important projects and deciding related issues.

Ministry of Oil and Gas

It has the overall responsibility of exploration and production of oil and gas, along with their refining, distribution and marketing, import, export, and conservation.

Planning commission or Niti Ayog

The Power and Energy, Energy Policy and Rural Energy Division of the Planning commission guides the energy policies of the country

Central Electricity Authority (CEA)

The CEA assists the Ministry of Power in all the technical and techno-economic matters.

Indian Renewable Energy Development Agency (IREDA)

The IREDA was established in 1987 as a non-banking financial company under the administrative control of the Ministry of Non-Conventional Energy Sources (MNES), to provide loans for renewable energy projects. Subsequently energy efficiency and energy conservation projects were added to its portfolio.

Bureau of Energy Efficiency (BEE)

The BEE, established under the Energy Conservation Act of 2001, has introduced labelling requirements and building codes to reduce the energy intensity of GDP growth. For instance, the Energy Conservation Building Code (ECBC) is aimed at maximising energy utilisation in commercial buildings, by using Leadership in Energy and Environmental Design (LEED) certification standards, and customising buildings based on location temperatures. The BEE is comprised of ministers from Central and State energy-related agencies. The BEE is working with key industries, including cement, aluminium, and paper and pulp, to establish voluntary EE practices. It is also drafting standards for energy-labelling, building codes, and certification programs, among other initiatives.

In February 2011, India's Bureau of Energy Efficiency (BEE) adopted new quality standards for solid state lighting, a process greatly accelerated as a result of SEAD, facilitated technical exchange between BEE and the United States Department of Energy. These standards are in the process of being notified through the Bureau of Indian Standards. In March, India also launched new internationally harmonized efficiency labels for laptops, drawing from the Energy Star programme.
The government created the Central Electricity Regulatory Commission) vested with jurisdiction by incorporating the Electricity Laws (Amendment) Act 1998, to regulate the tariff of bulk electric power, i.e. the generation and inter-state transmission of power, with effect from May 15, 1999.
It has been followed by the institution of 24 other State Electricity Regulatory Commissions (SERCs) in the states, excepting Nagaland and Arunachal Pradesh, with the authority to decide intra-state transmission and distribution/retail tariffs. This step was a key outcome of process of reform in the power sector.

The Petroleum and Natural Gas Regulatory Board (PNGRB), was established in June 2007.
Regulations supporting the development of renewable energy in India are the Electricity Act of 2003 and the National Electricity Policy of 2005. The Electricity Act of 2003 stipulates purchase of a certain percentage of the power procurement by distribution utilities from renewable energy sources. Under this act, implementation of the renewable portfolio obligation (RPO) is to be

guided by the regulatory provisions issued by the respective State Electricity Regulatory Commissions (SERCs). The National Electricity Policy of 2005 also mandates that the share of electricity from non-conventional sources has to be increased progressively. Several other incentives in the form of generation based incentives (GBI),feed-in-tariffs(FIT),depreciation benefits and tax incentives have also been introduced.

In March 2011, the Government of India launched the Renewable Energy Certificates (REC) – a market-based mechanism – to drive renewable energy development and spur further investments.

The CERC has passed regulations to promote growth in the renewable sector, such as the regulation on certificates for generation of RE, the regulation designating the National Load Dispatch Centre as the implementing agency, and regulations on renewable energy tariff-determination. The Indian administration has passed laws to promote renewable energy. The National Electricity Policy of 2005 and the Tariff Policy of 2006 promote RE investment by pricing it competitively with conventional energy. The Electricity Act of 2003 requires state electricity boards to facilitate the supply and distribution of RE, along with traditional electricity.

The CERC has notified tariff regulations for the determination of tariffs for RES projects. The regulations are formulated to promote the development of RE projects, to remove ambiguity on project returns, debt repayment assurance, etc. The regulations complement the National Action Plan on climate change, which specifies that minimum renewable purchase standards be set at 5% for total power purchases for FY10, and should be increased by 1% each year for ten years.
SERCs roles include tariff regulation and promotion of co-generation, and electricity generation from renewable.

Maintaining stable grid operation while increasing renewable power generation to meet renewable obligation quotas Although the central government intends to promote RE, its efforts are hampered by inconsistent implementation by the States and by the lack of a central RE law. Some States have set relatively high renewable portfolio standards (RPS – renewable energy targets), some have set low targets, and some have not yet set any targets. Enforcement could also be stronger. The co-existence of RPS schemes and feed-in tariffs needs to be well-managed. A misalignment of state targets with national objectives has also been identified as a key barrier, as well as the limited framework for regulation of inter-state renewable power transmission, based on resource availability.

1.8. Distributed Energy Generation

Distributed energy, also district or decentralized energy is generated or stored by a variety of small, grid-connected devices referred to as distributed energy resources (DER) or distributed energy resource systems.

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 electricity 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.

DER systems typically use renewable energy sources, including small hydro, biomass, biogas, solar power, wind power, and geothermal power, and increasingly 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 and improve security of supply.

Types of DER systems

Distributed energy resource (DER) systems are small-scale power generation or storage technologies (typically in the range of 1 kW to 10,000 kW) used to provide an alternative to or an enhancement of the traditional electric power system. DER systems typically are characterized by high initial capital costs per kilowatt. DER systems also serve as storage device and are often called Distributed energy storage systems (DESS).

Cogeneration

Distributed cogeneration sources use steam turbines, natural gas-fired fuel cells, microturbines or reciprocating engines to turn generators. The hot exhaust is then used for space or water heating, or to drive an absorptive chiller for cooling such as air-conditioning. In addition to natural gas-based schemes, distributed energy projects can also include other renewable or low carbon fuels including biofuels, biogas, landfill gas, sewage gas, coal bed methane, syngas and associated petroleum gas.

Delta-ee consultants stated in 2013 that with 64% of global sales the fuel cell micro combined heat and power passed the conventional systems in sales in 2012. 20.000 units where sold in Japan in 2012 overall within the Ene Farm project. With a Lifetime of around 60,000 hours. For PEM fuel cell units, which shut down at night, this equates to an estimated lifetime of between ten and fifteen years. For a price of $22,600 before installation. For 2013 a state subsidy for 50,000 units is in place.

In addition, molten carbonate fuel cell and solid oxide fuel cells using natural gas, such as the ones from FuelCell Energy and the Bloom energy server, or waste-to-energy processes such as the Gate

Solar power

Photovoltaics, by far the most important solar technology for distributed generation of solar power, uses solar cells assembled into solar panels to convert sunlight into electricity. It is a fast-growing technology doubling its worldwide installed capacity every couple of years. PV systems range from distributed, residential, and commercial rooftop or building integrated installations, to large, centralized utility-scale photovoltaic power stations.

The predominant PV technology is crystalline silicon, while thin-film solar cell technology accounts for about 10 percent of global photovoltaic deployment. In recent years, PV technology has improved its sunlight to electricity conversion efficiency, reduced the installation cost per watt as well as its energy payback time (EPBT) and levelised cost of electricity (LCOE), and has reached grid parity in at least 19 different markets in 2014.

As most renewable energy sources and unlike coal and nuclear, solar PV is variable and non-dispatchable, but has no fuel costs, operating pollution, mining-safety or operating-safety issues. It produces peak power around local noon each day and its capacity factor is around 20 percent.

Wind power

Another source is small wind turbines. These have low maintenance, and low pollution, however as with solar, wind energy is variable and non-dispatchable. Construction costs are higher ($0.80/W, 2007) per watt than large power plants, except in very windy areas. Wind towers and generators have substantial insurable liabilities caused by high winds, but good operating safety. In some areas of the US there may also be Property Tax costs involved with wind turbines that are not offset by incentives or accelerated depreciation. Wind also tends to complement solar. Days without sun tend to be windy, and vice versa. Many distributed generation sites combine wind power and solar power such as Slippery Rock University, which can be monitored online.

Hydro power

Hydroelectricity is the most widely used form of renewable energy and its potential has already been explored to a large extend or is compromised due to issues such as environmental impacts on fisheries, and increased demand for recreational access. However, using modern 21st century technology, such as wave power, can make large amounts of new hydropower capacity available, with minor environmental impact.

Modular and scalable Next generation kinetic energy turbines can be deployed in arrays to serve the needs on a residential, commercial, industrial, municipal or even regional scale. Microhydro kinetic generators neither require dams nor impoundments, as they utilize the kinetic energy of water motion, either waves or flow. No construction is needed on the shoreline or sea bed, which minimizes environmental impacts to habitats and simplifies the permitting process. Such power generation also has minimal environmental impact and non-traditional microhydro applications can be tethered to existing construction such as docks, piers, bridge abutments, or similar structures.

Waste-to-energy

Municipal solid waste (MSW) and natural waste, such as sewage sludge, food waste and animal manure will decompose and discharge methane-containing gas that can be collected and used as fuel in gas turbines or micro turbines to produce electricity as a distributed energy resource. Additionally, a California-based company, Gate 5 Energy Partners, Inc. has developed a process that transforms natural waste materials, such as sewage sludge, into biofuel that can be combusted to power a steam turbine that produces power. This power can be used in lieu of grid-power at the waste source (such as a treatment plant, farm or dairy).

Energy storage

A distributed energy resource is not limited to the generation of electricity but may also include a device to store distributed energy (DE). Distributed energy storage systems (DESS) applications include several types of battery, pumped hydro, compressed air, and thermal energy storage.

Flywheels

An advanced flywheel energy storage (FES) stores the electricity generated from distributed resources in the form of angular kinetic energy by accelerating a rotor (flywheel) to a very high speed of about 20,000 to over 50,000 rpm in a vacuum enclosure. Flywheels can respond quickly as they store and feed back electricity into the grid in a matter of minutes.

Vehicle-to-grid

Future generations of electric vehicles may have the ability to deliver power from the battery in a vehicle-to-grid into the grid when needed. An electric vehicle network has the potential to serve as a DESS.

PV storage

Common battery technologies used in today's PV systems include, the valve regulated lead-acid battery (lead–acid battery), nickel–cadmium and lithium-ion batteries. Compared to the other types, lead-acid batteries have a shorter lifetime and lower energy density. However, due to their high reliability, low self-discharge(4-6% per year) as well as low investment and maintenance costs, they are currently the predominant technology used in small-scale, residential PV systems, as lithium-ion batteries are still being developed and about 3.5 times as expensive as lead-acid batteries. Furthermore, as storage devices for PV systems are used stationary, the lower energy and power density and therefore higher weight of lead-acid batteries are not as critical as for electric vehicles.

Other rechargeable batteries that are considered for distributed PV systems include, sodium–sulfur and vanadium redox batteries, two prominent types of a molten salt and a flow battery, respectively.

1.9. Microgrid

A microgrid is a localized grouping of electricity generation, energy storage, and loads that normally operates connected to a traditional centralized grid (macrogrid). This single point of common coupling with the macrogrid can be disconnected. The microgrid can then function autonomously. Generation and loads in a microgrid are usually interconnected at low voltage. From the point of view of the grid operator, a connected microgrid can be controlled as if it were one entity.

Microgrid generation resources can include fuel cells, wind, solar, or other energy sources. The multiple dispersed generation sources and ability to isolate the microgrid from a larger network would provide highly reliable electric power. Produced heat from generation sources such as microturbines could be used for local process heating or space heating, allowing flexible trade off between the needs for heat and electric power.

Micro-grids were proposed in the wake of the July 2012 India blackout:

- ✓ Small micro-grids covering 30–50 km radius
- ✓ Small power stations of 5–10 MW to serve the micro-grids
- ✓ Generate power locally to reduce dependence on long distance transmission lines and cut transmission losses.

GTM Research forecasts microgrid capacity in the United States will exceed 1.8 gigawatts by 2018.

1.10. Environmental Impact of Electricity Generation

The environmental impact of electricity generation is significant because modern society uses large amounts of electrical power. This power is normally generated at power plants that convert some other kind of energy into electrical power. Each system has advantages and disadvantages, but many of them pose environmental concerns.

Water usage

The amount of water usage is often of great concern for electricity generating systems as populations increase and droughts become a concern. Still, according to the U.S. Geological Survey, thermoelectric power generation accounts for only 3.3 percent of net freshwater consumption with over 80 percent going to irrigation.

Steam-cycle plants (nuclear, coal, NG, solar thermal) require a great deal of water for cooling, to remove the heat at the steam condensors. The amount of water needed relative to plant output will be reduced with increasing boiler temperatures. Coal- and gas-fired boilers can produce high steam temperatures and so are more efficient, and require less cooling water relative to output. Nuclear boilers are limited in steam temperature by material constraints, and solar is limited by concentration of the energy source.

Thermal cycle plants near the ocean have the option of using seawater. Such a site will not have cooling towers and will be much less limited by environmental concerns of the discharge temperature since dumping heat will have very little effect on water temperatures. This will also not deplete the water available for other uses. Nuclear power in Japan for instance, uses no cooling towers at all because all plants are located on the coast. If dry cooling systems are used, significant water from the water table will not be used. Other, more novel, cooling solutions exist, such as sewage cooling at the Palo Verde Nuclear Generating Station.

Hydroelectricity's main cause of water usage is both evaporation and seepage into the water table.

Fossil Fuels

Most electricity today is generated by burning fossil fuels and producing steam which is then used to drive a steam turbine that, in turn, drives an electrical generator.

Such systems allow electricity to be generated where it is needed, since fossil fuels can readily be transported. They also take advantage of a large infrastructure designed to support consumer automobiles. The world's supply of fossil fuels is large, but finite. Exhaustion of low-cost fossil fuels will have significant consequences for energy sources as well as for the manufacture of plastics and many other things. Various estimates have been calculated for exactly when it will be exhausted. New sources of fossil fuels keep being discovered, although the rate of discovery is slowing while the difficulty of extraction simultaneously increases.

More serious are concerns about the emissions that result from fossil fuel burning. Fossil fuels constitute a significant repository of carbon buried deep underground. Burning them results in the conversion of this carbon to carbon dioxide, which is then released into the atmosphere. The estimated CO_2 emission from the world's electrical power industry is 10 billion tonnes yearly. This results in an increase in the Earth's levels of atmospheric carbon dioxide, which enhances the greenhouse effect and contributes to global warming. The linkage between increased carbon dioxide and global warming is well accepted, though fossil-fuel producers vigorously contest these findings.

Depending on the particular fossil fuel and the method of burning, other emissions may be produced as well. Ozone, sulfur dioxide, NO2 and other gases are often released, as well as particulate matter. Sulfur and nitrogen oxides contribute to smog and acid rain. In the past, plant owners addressed this problem by building very tall flue-gas stacks, so that the pollutants would be diluted in the atmosphere. While this helps reduce local contamination, it does not help at all with global issues.

Fossil fuels, particularly coal, also contain dilute radioactive material, and burning them in very large quantities releases this material into the environment, leading to low levels of local and global radioactive contamination, the levels of which are, ironically, higher than a nuclear power station as their radioactive contaminants are controlled and stored.

Coal also contains traces of toxic heavy elements such as mercury, arsenic and others. Mercury vaporized in a power plant's boiler may stay suspended in the atmosphere and circulate around the world. While a substantial inventory of mercury exists in the environment, as other man-made emissions of mercury become better controlled, power plant emissions become a significant fraction of the remaining emissions. Power plant emissions of mercury in the United States are thought to be about 50 tons per year in 2003, and several hundred tons per year in China. Power plant designers can fit equipment to power stations to reduce emissions.

Nuclear power

A large nuclear power plant may reject waste heat to a natural body of water; this can result in undesirable increase of the water temperature with adverse effect on aquatic life.

Emission of radioactivity from a nuclear plant is controlled by regulations. Abnormal operation may result in release of radioactive material on scales ranging from minor to severe, although these scenarios are very rare.

Mining of uranium ore can disrupt the environment around the mine. Disposal of spent fuel is controversial, with many proposed long-term storage schemes under intense review and criticism. Diversion of fresh or spent fuel to weapons production presents a risk of nuclear proliferation. Finally, the structure of the reactor itself becomes radioactive and will require decades of storage before it can be economically dismantled and in turn disposed of as waste.

Renewable Energy

Renewable power technologies can have significant environmental benefits. Unlike coal and natural gas, they can generate electricity and fuels without releasing significant quantities of CO2 and other greenhouse gases that contribute to climate change, however the greenhouse gas savings from a number of biofuels have been found to be much less than originally anticipated, as discussed in the article Indirect land use change impacts of biofuels.

Both solar and wind have been criticized from an aesthetic point of view. However, methods and opportunities exist to deploy these renewable technologies efficiently and unobtrusively: fixed solar collectors can double as noise barriers along highways, and extensive roadway, parking lot, and roof-top area is currently available; amorphous photovoltaic cells can also be used to tint windows and produce energy. Advocates of renewable energy also argue that current infrastructure is less aesthetically pleasing than alternatives, but sited further from the view of most critics.

Hydroelectricity

The major advantage of hydroelectric systems is the elimination of the cost of fuel. Other advantages include longer life than fuel-fired generation, low operating costs, and the provision of facilities for water sports. Operation of pumped-storage plants improves the daily load factor of the generation system. Overall, hydroelectric power can be far less expensive than electricity generated from fossil fuels or nuclear energy, and areas with abundant hydroelectric power attract industry.

However, there are several disadvantages of hydroelectricity systems. These include: dislocation of people living where the reservoirs are planned, release of significant amounts of carbon dioxide at construction and flooding of the reservoir, disruption of aquatic ecosystems and birdlife, adverse impacts on the river environment, potential risks of sabotage and terrorism, and in rare cases catastrophic failure of the dam wall.

Biomass

Electrical power can be generated by burning anything which will combust. Some electrical power is generated by burning crops which are grown specifically for the purpose. Usually this is done by fermenting plant matter to produce ethanol, which is then burned. This may also be done by allowing organic matter to decay, producing biogas, which is then burned. Also, when burned, wood is a form of biomass fuel.

Burning biomass produces many of the same emissions as burning fossil fuels. However, growing biomass captures carbon dioxide out of the air, so that the net contribution to global atmospheric carbon dioxide levels is small.

The process of growing biomass is subject to the same environmental concerns as any kind of agriculture. It uses a large amount of land, and fertilizers and pesticides may be necessary for cost-effective growth. Biomass that is produced as a by-product of agriculture shows some promise, but most such biomass is currently being used, for plowing back into the soil as fertilizer if nothing else.

Tidal

Tidal Turbines - Land constrictions such as straits or inlets can create high velocities at specific sites, which can be captured with the use of turbines. These turbines can be horizontal, vertical, open, or ducted and are typically placed near the bottom of the water column.

The main environmental concern with tidal energy is associated with blade strike and entanglement of marine organisms as high speed water increases the risk of organisms being pushed near or through these devices. As with all offshore renewable energies, there is also a concern about how the creation of EMF and acoustic outputs may affect marine organisms. Because these devices are in the water, the acoustic output can be greater than those created with offshore wind energy. Depending on the frequency and amplitude of sound generated by the tidal energy devices, this acoustic output can have varying effects on marine mammals (particularly those who echolocate to communicate and navigate in the marine environment such as dolphins and whales). Tidal energy removal can also cause environmental concerns such as degrading farfield water quality and disrupting sediment processes. Depending on the size of the project, these effects can range from small traces of sediment build up near the tidal device to severely affecting nearshore ecosystems and processes.

Tidal Barrage - Tidal barrages are dams built across the entrance to a bay or estuary that captures potential tidal energy with turbines similar to a conventional hydrokinetic dam. Energy is collected while the height difference on either side of the dam is greatest, at low or high tide. A minimum height fluctuation of 5 meters is required to justify the construction, so only 40 locations worldwide have been identified as feasible.

Installing a barrage may change the shoreline within the bay or estuary, affecting a large ecosystem that depends on tidal flats. Inhibiting the flow of water in and out of the bay, there may also be less flushing of the bay or estuary, causing additional turbidity (suspended solids) and less saltwater, which may result in the death of fish that act as a vital food source to birds and mammals. Migrating fish may also be unable to access breeding streams, and may attempt to pass through the turbines. The same acoustic concerns apply to tidal barrages. Decreasing shipping accessibility can become a socio-economic issue, though locks can be added to allow slow passage. However, the barrage may improve the local economy by increasing land access as a bridge. Calmer waters may also allow better recreation in the bay or estuary.

Wind power

Wind power harnesses mechanical energy from the constant flow of air over the surface of the earth. Wind power stations generally consist of wind farms, fields of wind turbines in locations with relatively high winds. A primary publicity issue regarding wind turbines are their older predecessors, such as the Altamont Pass Wind Farm in California. These older, smaller, wind turbines are rather noisy and densely located, making them very unattractive to the local population. The downwind side of the turbine does disrupt local low-level winds. Modern large wind turbines have mitigated these concerns, and have become a commercially important energy source. Many homeowners in areas with high winds and expensive electricity set up small windmills to reduce their electric bills.

A modern wind farm, when installed on agricultural land, has one of the lowest environmental impacts of all energy sources:

- ✓ It occupies less land area per kilowatt-hour (kWh) of electricity generated than any other renewable energy conversion system, and is compatible with grazing and crops.
- ✓ It generates the energy used in its construction within just months of operation.
- ✓ Greenhouse gas emissions and air pollution produced by its construction are small and declining. There are no emissions or pollution produced by its operation.
- ✓ Modern wind turbines rotate so slowly (in terms of revolutions per minute) that they are rarely a hazard to birds.

Geothermal power

Geothermal energy is the heat of the Earth, which can be tapped into to produce electricity in power plants. Warm water produced from geothermal sources can be used for industry, agriculture, bathing and cleansing. Where underground steam sources can be tapped, the steam is used to run a steam turbine. Geothermal steam sources have a finite life as underground water is depleted. Arrangements that circulate surface water through rock formations to produce hot water or steam are, on a human-relevant time scale, renewable.

While a geothermal power plant does not burn any fuel, it will still have emissions due to substances other than steam which come up from the geothermal wells. These may include hydrogen sulfide, and carbon dioxide. Some geothermal steam sources entrain non-soluble minerals that must be removed from the steam before it is used for generation; this material must be properly disposed. Any (closed cycle) steam power plant requires cooling water for condensers; diversion of cooling water from natural sources, and its increased temperature when returned to streams or lakes, may have a significant impact on local ecosystems.

Removal of ground water and accelerated cooling of rock formations can cause earth tremors. Enhanced geothermal systems (EGS) fracture underground rock to produce more steam; such projects can cause earthquakes. Certain geothermal projects (such as one near Basel, Switzerland in 2006) have been suspended or canceled owing to objectionable seismicity induced by geothermal recovery. However, risks associated with "hydrofracturing induced seismicity are low compared to that of natural earthquakes, and can be reduced by careful management and monitoring" and "should not be regarded as an impediment to further development of the Hot Rock geothermal energy resource".

Solar power

Currently solar photovoltaic power is used primarily in Germany and Spain where the governments offer financial incentives. In the U.S., Washington State also provides financial incentives. Photovoltaic power is also more common, as one might expect, in areas where sunlight is abundant.

It works by converting the sun's radiation into direct current (DC) power by use of photovoltaic cells. This power can then be converted into the more common AC power and fed to the power grid.

Solar photovoltaic power offers a viable alternative to fossils fuels for its cleanliness and supply, although at a high production cost. Future technology improvements are expected to bring this cost down to a more competitive range.

Its negative impact on the environment lies in the creation of the solar cells which are made primarily of silica (from sand) and the extraction of silicon from silica may require the use of fossil fuels, although newer manufacturing processes have eliminated CO2 production. Solar power carries an upfront cost to the environment via production, but offers clean energy throughout the lifespan of the solar cell.

Large scale electricity generation using photovoltaic power requires a large amount of land, due to the low power density of photovoltaic power. Land use can be reduced by installing on buildings and other built up areas, though this reduces efficiency.

1.11. Energy Conservation

Energy saving is in principle the results of the reduction of the total amount of consumed energy without seriously affecting the process or the end results. Even though energy conservation reduces energy services, it can result in increased environmental quality, national security, personal financial security and higher savings. It is at the top of the sustainable energy hierarchy. It also lowers energy costs by preventing future resource depletion

Any reduction in the consumption of Energy always yields greater amounts of energy savings in the production sites.

Methods / Techniques used for achieving reduction of consumed energy.

- ✓ Implementing systems that manage the transmition and distribution of energy, efficiently and effectively.
- ✓ Implementing systems that control the flow of reactive power
- ✓ Implementing controlling systems that reduce the maximum demand
- ✓ Implementing systems that utilise the excess or rejected energy. Cogeneration of electricity with heating or cooling
- ✓ Thermal insulation of pipes and other components, or even rooms and entire houses, so that the undesirable heat losses or gains are minimized
- ✓ Substitution of old components and/or machinery like motors, burners, compressors and chillers, with new ones of higher efficiency so that the consumption of energy is consumed without affecting the process or the result.

Petroleum Conservation Research Association (PCRA) www.pcra.org is an Indian government body created in 1977 and engaged in promoting energy efficiency and conservation in every walk of life. In the recent past PCRA has done mass media campaigns in television, radio & print media. An impact assessment survey by a third party revealed that due to these mega campaigns by PCRA, overall awareness level have gone up leading to saving of fossil fuels worth crores of rupees(Indian currency) besides reducing pollution.

Bureau of Energy Efficiency is an Indian governmental organization created in 2001 responsible for promoting energy efficiency and conservation.