Geography

ENERGY RESOURCES

Energy has been described as the capacity to do work. The behavior of energy is described by the two laws of the thermodynamics. Early humans had modest energy requirements, mostly food and fuel for fires to cook and keep warm. In today's society, we consume 110 times more energy per person as compared to early humans. Today, energy is an essential input for the all economic development and improvement of quality of life. Matter that stores energy is called a fuel. Energy resources are all forms of fuels used in the modern world, that can produce heat, power life, move objects, generate electrical energy, or for other forms of energy conversion processes. Energy resources can be roughly classified in three categories: 1. Non-Renewable Sources: sources of energy are only available in limited amounts and develop over a longer period of time. These are also known as “dirty” or “Conventional Source” because they can endanger the environment or human health and which are being traditionally used for many decades. These resources are found in specific parts of the world, making them more plentiful in some nations than others. The generation of energy from these resources is relatively less expensive. Examples: Coal, Petroleum, Natural Gases, Oil, Nuclear Energy etc. Disadvantages: • Highly polluting. • Available only in few places. • High running cost. • Limited supply and will one day get exhausted.· 2. Renewable Sources: energy available in unlimited amount in nature since these can be renewed over relatively short period of time. These are also known as “clean” or “Non-conventional” Source because they have very limited environment impacts and which are considered for large scale use after oil crisis of 1973. These resources are found in every country like every country has access to sunshine and wind. In present time, the generation of renewable energy is often more expensive but the cost of renewable energy is now falling so fast that it should be a consistently cheaper source of electricity generation than traditional fossil fuels in coming years. Examples: Solar energy, Wind energy, Hydro power, Ocean thermal energy, Tidal or Wave energy, geothermal energy etc. The Government has set a target of installing 175 GW of renewable energy capacity by the year 2022 which includes 100 GW from solar, 60 GW from wind, 10 GW from Biomass and 5 GW from Small Hydro. Total installed RE capacity according to MNRE, to 86.32 GW as of January 31, 2020. Wind leads with 37.61 GW, Solar power at 34.03 GW, with Bio-Power at 10 GW and small hydro at 4.68GW. Though due to the misuse, these resources are not present in the pure form as they are and therefore resources such as water, sunlight, should be used with care and focus should be on managing the quantity as well as the quality of it, so our future generation can also use them.

Disadvantages: • Unreasonable supply. • Usually produced in small quantities. • Often very difficult to store. • Currently per unit cost of energy is more compared to other types. 3. Alternate Emerging Energy Sources: Alternative energy is energy that does not comes from fossil fuels and thus produces little to no greenhouse gases. This means that energy produced from alternative sources does not contribute to the greenhouse effect that causes climate change. These energy sources are referred to as "alternative" because they represent the alternative to coal, oil, and natural gas, which have been the most common sources of energy since the Industrial Revolution. Alternative energy, however, should not be confused with renewable energy, although many renewable energy sources can also be considered alternative. Solar power, for example, is both renewable and alternative because it will always be abundant and it emits no greenhouse gases. Nuclear power, however, is alternative but not renewable, since it uses uranium, a finite resource. Examples: energy from waste, Hydrogen energy, Fuel cells, Alcohol as energy source, Energy plantation etc.

BENEFITS OF ALTERNATIVE ENERGY SOURCES: • Alternative energy is considered a reliable source of energy because the technological development in recent years allowed these clean energy sources to enter more and more into the global energy. • Alternative energy is good for the environment that produces very low emissions or zero emission

Alternative energy represents a renewable energy source that never runs out. • Alternative energy sources are the solution to getting energy independence for every household. It enables the poor to stretch their period of economic activity and their children can help them in daily chores and then study in the evenings. • Lower dependency on fuel wood and other household fuel sources reduces the drudgery of women by eliminating the distances they travel for fuel collection. • Reduce or eliminate health problems associated with using conventional cook stoves, including respiratory diseases and eye problems. • Alternative energy sources can provide local employment opportunities through direct use of energy in small-scale industry and agriculture, through construction, repair, and maintenance of energy devices, or through the sale of energy to local utilities.

GROWING ENERGY NEEDS

We cannot imagine life without energy. Energy is an important input for development. It aims at human welfare covering household, agriculture, industry, mining, transportation, lighting, cooling and heating buildings all need energy. Developed countries continue to consume huge amounts of energy while demand is increasing in developing countries. Growing populations and increasing standards of living for many people in developing countries will place even more demand on energy resources. Global energy needs are expected to grow, with fossil fuels remaining the dominant source. Oil, coal and gas are the primary energy resource. Approximately 80% of the world's energy is produced by fossil fuels. However, in France produce enough nuclear energy to meet 70% of country's requirement. Between 2005 and 2030, energy needs are projected to expand by 55 per cent and energy consumption is expected to increase by 50 per cent. Global variations in energy use: Energy consumption per head is a reliable indicator of a country's level of economic development. In Canada and the USA consumption per head is double that of Europe and more than 800 times that of developing countries. A person in a rich country consumes almost as much energy in a single day as one person does in a whole year in a poor country. Developing countries face a huge energy challenge in the 21st Century: meeting the needs of billions of people who still lack access to basic, modern energy services while also participating in a global transition to clean, low-carbon energy systems. Indian Scenario: • The major sources for commercial energy in India are coal, oil products, natural gas and electricity. Apart from commercial energy, a large amount of non-commercial energy sources in the form of firewood, agriculture waste and animal residue, draught animal and human power are used. The main drivers of this increase are the accompanying structural change of economic growth and a rise in population together with rapid urbanization. • Industrial sector is the largest consumer of energy consuming about 50% of the total commercial energy produced in our country. • Transport sector is the largest consumer of petroleum products mainly in the form of high speed diesel and gasoline. • With increase mechanisation and modernisation of its activities, the agricultural sector's consumption of commercial energy has grown. • In the domestic sector, the consumption of natural fuel (mostly wood) energy is very high. Around 78% of rural and 30% of urban households depend on fire wood. However, the mix of traditional fuels in the national energy mix is decreasing as more efficient commercial fuels are increasingly substituting these. Different fuels have different levels of energy content, which can be measured in terms of equivalent energy released through combustion. The higher the energy content the higher the fuel quality, which is inversely proportional to its chemical complexity.

High quality fuels are gases while low quality fuels are solids or liquids. The highest energy content fuel is hydrogen, which is also the simplest chemical component in existence. • Energy Content of some Combustibles (in MJ/kg): Hydrogen (142), Methane (55.5), Natural gas (47.2), Diesel (45.3), Crude oil (41.9), Coal- Anthracite (31.4), Coal- Bituminous (23.9), Wood (17.1). • Oil products have the highest energy contents among the potential fuels for power generation, but they also have the highest prices. • Coal products are among the best value from an energy contents and price standpoint, but new regulations to control emissions are making the fuels inherently more expensive. • Biomass and other renewable fuel sources can offer among the best value from a price and environmental standpoint. • Energy contents of some fuels are:.

Agricultural residue or agro-residue describes all organic material produced as by-products after harvesting and processing of agricultural crops. Agro-residues are non-wood and a rich source of cellulose with lignin. These may include stalk, cane, seed pod and leaves etc. Agro-residues are annually renewable and abundantly available at lower price. Agro-residues are of two types: 1. Field residues: The materials left in an agricultural field after the crop has been harvested. It includes leaves, banana pseudo stems and leaves, cornhusk, seed pods, kapok seed pods and cotton stalks etc. Process residues: The materials left after the crop is processed into a usable resource. Examples: bagasse, pea peel, wheat and rice straw etc. Uses of Agro-Residues as Biomass (second generation biofuel) Energy: About 32% of the total primary energy use in the country is still derived from biomass and more than 70% of the country's population depends upon it for its energy needs. Potential: The current availability of biomass in India is estimated at about 500 million metric tonnes per year. Studies sponsored by the Ministry has estimated surplus biomass availability at about 120-150 million metric tonnes per annum covering agricultural and forestry residues corresponding to a potential of about 18,000 MW. This apart, about 7000 MW additional power could be generated through bagasse based cogeneration in the country's 550 Sugar mills, if these sugar mills were to adopt technically and economically optimal levels of cogeneration for extracting power from the bagasse produced by them. Current Status: A total capacity of 9806 MW has been installed (Grid Connected – 9131 MW and Offgrid – 675 MW). Benefits of using agro-residue as a source of energy: • The production of fuels from biomass energy plantations is comparatively easy and reliable. • Agro-residue is highly versatile, easy to store (or to harvest on demand) and available in almost all geographical locations. • Many employment opportunities are created in rural communities. • Options for producing electricity on scales suited to clusters of rural townships. • Low capital investment is required, with a relatively fast payback period. • Local fuels reduce

demand for foreign exchange by substituting for imported fuels/oils. • Local resources can be exploited to the full with use of local skills and technologies, and this result in lower energy costs; and helps build a pool of local experience/expertise. • Bio-manure is the safest source of plant nutrients, when compared to inorganic chemical fertilizers.

Biomass is an ideal choice for rural, industrial and domestic application. • Agro-residue encourages self-sustaining employment and income generation with greater opportunities for decentralizing energy production systems. • Cleaner environment, better sanitation, improved hygiene and the use of materials previously wasted. Technology: The thermo chemical processes for conversion of agro-residue to useful products involve combustion, gasification or pyrolysis, hydrolysis, Landfill gas recovery, incineration, pelletization and anaerobic digestion etc. Various uses: 1. In a biomass power plant the agro-residue is burnt in a boiler to produce steam that then drives a turbine and a generator to produce electricity. Example: The Indian Government has approved the establishment of two biomass plants at Ambala and Karnal.These will comprise a 12 MW power plant in Ambala and fired by agro-residues (i.e. rice straw, rice husk, wheat straw, bagasse and cotton stalks). The second plant at Karnal will have capacity of 5.5MW and will also burn agro-residues. 2. Agro-residue can be converted to liquid biofuels such as methanol and ethanol or used directly as a fuel. 3. Anaerobic digestion is the process of biological digestion/degradation/decomposition of agro-residue in the absence of oxygen. During this process a gaseous fuel usually called biogas is produced. The slurry obtained from anaerobic digestion makes an excellent soil conditioner and plant food. 4. Consolidating and packaging loose agro-waste into a high density unit is called biomass ‘briquetting’. Briquettes are an excellent fuel capable of replacing fossil fuels for a number of uses. 5. Incineration is the process of directly burning agro-residue in the presence of excess air (oxygen) at high temperatures (about 8000 0C), which results in heat energy, inert gases and ash. 6. Bio-diesel is the name given to a clean burning fuel produced from renewable sources such as soybean, vegetable residues. 7. Bio-ethanol is produced from crops with high sugar or starch content. 8. Case Study: Mini-Power-Plants India: The Institute of Solid Waste Research and Ecological Balance at Visakhapatnam (INSWAREB) took advantage of the low-cost husk residues that remained from rice milling for generating electricity in energy-starved India. The Institute exploited the energy content of rice husk (at 12.5 MJ/kg) and developed ‘mini-power plants’ with capacity of 1-2 MW suitable for rural communities. Rice husk can be burned and power generated, and the rice husk ash (RHA) obtained as a by-product. RHA has considerable industrial value and

a number of mini-power plants have been established on the basis of earnings from power and RHA The Sun has been worshiped as a life-giver to our planet since ancient times. India is endowed with vast solar energy potential. About 5,000 trillion kWh per year energy is incident over India's land area with most parts receiving 4-7 kWh per sq. m per day. National Institute of Solar Energy has assessed the Country's solar potential of about 748 GW assuming 3% of the waste land area to be covered by Solar PV modules. National Solar Mission (NSM) was launched on 11th January, 2010. The Mission targets installing 100 GW grid-connected solar power plants by the year 2022. In order to achieve it, Government of India have launched various schemes to encourage generation of solar power in the country like Solar Park Scheme, VGF Schemes, CPSU Scheme, Defence Scheme, Canal bank & Canal top Scheme, Bundling Scheme, Grid Connected Solar Rooftop Scheme etc. India achieved 5th global position in solar power deployment by surpassing Italy. Sun is the primary source of energy. Sun's energy each day is 600 times greater than produced from all other sources. Solar energy can be used directly (ex. direct heating) or indirectly (ex. biomass energy) for the human welfare. Some important solar harvesting devices: 1. Solar heating for homes: In solar heated buildings, sunspaces are built on the south side of the structure which acts as large heat absorbers. The floors of sunspaces are usually made of tiles or bricks that absorb heat throughout the day and then release heat at night when it's cold. 2. Solar water heating: The solar energy collector heats the water, which then flows to a well insulated storage tank. 3. Solar cookers: The heat produced by the sun can be directly used for cooking using solar cookers. A solar cooker is a metal box which is black on the inside to absorb and retain heat. The lid has a reflective surface to reflect the heat from the sun into the box. The box contains black vessels in which the food to be cooked is placed. 4. Solar desalination: systems for converting saline or brackish water into pure distilled water. 5. Photovoltaic energy: The solar technology which has the greatest potential for use throughout the world is that of solar photo voltaic cells which directly produce electricity from sunlight using photovoltaic (PV) (also called solar) cells. 6. Solar power plant: Solar energy is harnessed on a large scale by using conclave reflectors. 7. Concentrated Solar Power (CSP): It uses lenses or mirrors and tracking systems to concentrate sunlight, then use the resulting heat to generate electricity from conventional steam-driven turbines. It is also called concentrated solar thermal Biomass Energy: Biomass is organic material which has stored sun light in the form of chemical energy. Because plants and trees depend on sunlight to grow, biomass energy is a form of stored solar energy. HYDROPOWER • Hydropower

refers to the conversion of energy from flowing water into electricity. Historically, one of the first uses of hydro power was for mechanical milling, such as grinding grains. Today, modern hydro plants produce electricity using turbines and generators. Hydropower technologies generate power by using a dam or diversion structure to alter the natural flow of a river or other body of water. • British-American engineer James Francis developed the first modern water turbine. • In 1882, the world's first hydroelectric power plant began operating along the Fox River in the United States. • The oldest Hydropower power plant in India is in Darjeeling District in West Bengal. Its installed capacity is 130KW and was commissioned in the year 1897. • The hydropower potential of India is around 1, 45,000 MW and at 60% load factor, it can meet the demand of around 85, 000 MW. Around 26% of Hydropower potential has been exploited in India. • Chamera - II HE Project (300 MW) in Distt. Chamba, HP. has been completed in a record period is Four & Half years. • Three gauges project in China on Yang-Yang river is the largest hydropower station in the world having installed capacity of around 18,200 MW. • The world's Largest operating Hydro Electric Power Station is ITAIPU with installed capacity of 12,600 MW. It is located at the Border of Brazil and Paraguay. • Hydropower can be categorized into following sizes: Micro (Up to 100 KW), Mini (101KW to 2MW), Small (2 MW to 25MW), Mega: Hydro projects with installed capacity >= 500 MW, Thermal Projects with installed capacity >=1500 MW. • There are three main types of hydro plants. 1. Impoundment facilities: The most common technology which uses a dam to create a large reservoir of water. Electricity is made when water passes through turbines in the dam. 2. Pumped storage facilities are similar but have a second reservoir below the dam. Water can be pumped from the lower reservoir to the upper reservoir, storing energy for use at a later time. 3. Run-of-river facilities rely more on natural water flow rates, diverting just a portion of river water through turbines, sometimes without the use of a dam or reservoirs. Advantages of Hydropower: • Hydropower is fueled by water, so it's a clean fuel source, meaning it won't pollute the air like power plants that burn fossil fuels, such as coal or natural gas. • Hydroelectric power is a domestic source of energy, allowing each state to produce their own energy without being reliant on international fuel sources. • The energy generated through hydropower relies on the water cycle, which is driven by the sun, making it a renewable power source, making it a more reliable and affordable source than fossil fuels that are rapidly being depleted. • Impoundment hydropower creates reservoirs that offer a variety of recreational opportunities, notably fishing, swimming, and boating. Most water power installations are required to provide some public access to the reservoir

to allow the public to take advantage of these opportunities. • Some hydropower facilities can quickly go from zero power to maximum output. Because hydropower plants can generate power to the grid immediately, they provide essential back-up power during major electricity outages or disruptions. • In addition to a sustainable fuel source, hydropower efforts produce a number of benefits, such as flood control, irrigation, and water supply. Drawbacks of Hydropower: • To produce hydroelectric power, large areas of forest and agricultural lands are submerged. • Silting of the reservoirs reduces the life of the hydroelectric power installations. • Water is required for many other purposes besides power generation. These include domestic requirements, growing agricultural crops and for industry. This gives rise to conflicts. • The use of rivers for navigation and fisheries becomes difficult once the water is dammed for generation of electricity. • Resettlement of displaced persons is a problem for which there is no ready solution. • In certain regions large dams can induce seismic activity which will result in earthquakes. There is a great possibility of this occurring around the Tehri dam in the Himalayan foothills. Shri Sunderlal Bahuguna, the initiator of the Chipko Movement has fought against the Tehri Dam for several years. An energy source that has zero emission provides electricity around the clock and propels our society into the future. Nuclear power is a clean and efficient way of boiling water to make steam, which turns turbines to produce electricity. In all nuclear power plants, the process of making electricity causes radioactivity. The radioactivity comes from the atom. Atom consists of nucleus and electrons in orbits. Energy is obtained from the nucleus in the following methods: 1. Nuclear Fusion: Breaking a heavy nucleus into 2 or more than 2 smaller lighter nuclei. 2. Nuclear Fission: Combining 2 lighter nuclei to form a heavy nucleus. • Uncontrolled chain reaction: A heavy nucleus in bombarded with a neutron. It splits into lighter nuclei releasing 2 or more neutrons. Each neutron again bombards nuclei of atom and splits further and further. The neutrons and thereby the fission reaction exponentially increases. Ex: Atom bomb. • Controlled chain reaction: A heavy nucleus in bombarded with a neutron. It splits into lighter nuclei releasing 2 or more neutrons. But in this case, except one neutron all the other neutrons are absorbed. So, only one neutron is left. This single neutron again bombards nuclei of atom and splits further and further. Again only one neutron is left behind and the others are absorbed. So, the reaction is controlled. Ex: Nuclear generator. In 1938 two German scientists Otto Hahn and Fritz Strassman demonstrated nuclear fission. The first large-scale nuclear power plant in the world became operational in 1957 in Pennsylvania, United State. Dr. Homi Bhabha was the father of Nuclear

Power development in India. As of March 2018, India has 22 nuclear reactors in 7 nuclear power plants, with a total installed capacity of 6,780 MW that supplied 3.22% of Indian electricity. 7 more reactors are under construction with a combined generation capacity of 4,300 MW. The nuclear reactors use Uranium 235 to produce electricity. Energy released from 1kg of Uranium 235 is equivalent to that produced by burning 3,000 tons of coal. India has uranium mines (first operation in 1967) in Jauguda village in the Purbi Singhbhum district of Jharkhand. There are deposits of thorium in Kerala and Tamilnadu. Applications of Nuclear Energy: • Nuclear technology. •

Nuclear medicine.

Nuclear Technology is used in Industries. • Agricultural uses of nuclear technology. • Environmental uses of nuclear technology. • Biological Experimentations. • Hospitals, doctors, dentists, and even veterinarians use to diagnose and treat illnesses, such as cancer. They are also used to study diseases. • Scientific institutions use it in laboratory experiments and research. • Supply electricity to satellites and to spacecraft that are sent on missions to the outermost regions of our solar system. • Engineering Projects. • Neutron Activation Analysis. Advantages of Nuclear Energy: Nuclear energy offers many advantages as the emissions-free workhorse of our energy grid. Its unique value cannot be found in any other energy source. 1. Compared to the surface occupied by a solar power plant, a wind farm or a biomass facility, a nuclear power station will occupy a smaller surface of land and will generate huge amounts of clean electricity. 2. Nuclear Energy is Powerful and Efficient: Coal generates 32.5 MJ/kg (Megajoules/kilogram), while uranium (breeder) generates 810,000,000 MJ/kg, so almost 25,000 times more. 3. The future operational costs of the nuclear power plant will be much smaller. 4. Nuclear Energy is a Cleaner Energy Source. 5. On the energy market today, the price of nuclear energy is stable and pretty low compared with the price of energy generated from fossil fuels. 6. Nuclear reactors are considered today very reliable machines that can operate in safe conditions for several decades. 7. Nuclear generates jobs: Nuclear energy provides more than 100,000 well-paid, long-term jobs and supports local economies. 8. Nuclear boosts international development: Nuclear energy helps developing nations meet sustainable development goals. 9. Nuclear powers electric vehicles: Electrified transportation promises to reduce carbon emissions. When powered by carbon-free nuclear energy, electric vehicles can reach their full potential.

Disadvantages of Nuclear Energy: 1. It's not a renewable energy source. 2. The rods need to be changed periodically. This has impacts on the environment due to disposal of nuclear waste. 3. The reaction releases very hot waste water that damages aquatic ecosystems. 4. Uranium mining can cause high levels of pollution and also health risks for mine workers. 5. Transport of uranium and nuclear fuels carries potential pollution and environmental contamination risks. 6. Building new nuclear plants is a huge investment, especially for developing countries. 7. National Risk: Nuclear Power Plants and Nuclear Waste Facilities Are Constant Targets for Terrorist Groups. 8. The most severe Nuclear Disasters in the Recent History are the following: the Three Mile Island nuclear accident in March 28, 1979 (the U.S.), the Chernobyl disaster in April 26, 1986 (Ukraine), and the Fukushima nuclear disaster in March 11, 2011 (Japan). Nuclear power can have a future as energy source for mankind only if nuclear waste will no longer be produced, which means that only the nuclear fusion reaction will become a main source of clean power for us.

Biogas

• Biogas is a type of biofuel that is produced from the decomposition (anaerobic fermentation) of organic matter (plant material and animal waste, garbage, waste from households and some types of industrial wastes, such as fish processing, dairies, and sewage treatment plants) by the action of bacteria. • Biogas production is a well-established process for energy generation, nutrient recovery, and valorization of organic residues. Typically, the biogas is composed of methane, carbon dioxide, hydrogen sulphide, water vapour and other impurities. • Due to the high content of methane, typically 50-75%, biogas is flammable and therefore produces a deep blue flame. • Biogas is known as an environmentally-friendly energy source because it alleviates two major environmental problems simultaneously: first, the global waste epidemic that releases dangerous levels of methane gas every day and second the reliance on fossil fuel energy to meet global energy demand. • Biogas plant is a unit which converts organic waste matter into useful gaseous fuel (methane and carbon dioxide) and organic fertilizer as byproduct in the form of slurry.

The potential is about 12 million family type biogas plants based on estimated availability of cattle dung in the country. A total of 4.31 million family type biogas plants have been setup in the country. • The cost of biogas plant varies from place to place and size of the plant. Average cost of 2 cubic meter size biogas plant is about Rs. 17,000. • The Ministry is implementing a National Biogas and Manure Management Programme (NBMMP), for setting up of family type biogas

plants, since 1981-82. Geothermal Energy • Geothermal energy is the heat that comes from the sub-surface of the earth. To produce power from geothermal energy, wells are dug a mile deep into underground reservoirs to access the steam and hot water there, which can then be used to drive turbines connected to electricity generators. • There are four major types of geothermal energy resources: Hydrothermal, Geopressurised brines, Hot dry rocks and Magma. • According to the International Renewable Energy Agency (IRENA), geothermal energy has grown steadily from around 10GW worldwide in 2010 to 13.3GW in 2018. • The world's largest producer of geothermal energy is "The Geysers" in California (U.S.), spread over 117 square kilometres and formed of 22 power plants, with an installed capacity of over 1.5 GW. • The GSI (Geological Survey of India) has identified 350 geothermal energy locations in the country. The most promising of these is in Puga valley of Ladakh. The estimated potential for geothermal energy in India is about 10000 MW. • There are seven geothermal provinces in India: the Himalayas, Sohana, West coast, Cambay, SonNarmada-Tapi (SONATA), Godavari, and Mahanadi.