Renewable Energy

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Lesson No.	Lesson Title
Lesson 1	Introduction to renewable energy, classification of energy sources, contribution of these sources in the agricultural sector
Lesson 2	Familiarization with biomass utilization, biofuel production, biogas, bioalcohol, biodiesel, and biooil production and their utilization as bioenergy resources
Lesson 3	Types of biogas plants and gasifiers
Lesson 4	Introduction of solar energy, Solar Energy Technologies, Solar Photovoltaic Systems, Solar Photovoltaic Application, Solar Thermal System, Solar energy gadgets, their application in agriculture and allied activities
Lesson 5	Introduction of wind energy, Application of wind energy, Environmental impact of wind energy farming, Economic feasibility of wind energy farms

Farming is not just a job, it's a passion!

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Course Name	Renewable Energy
Lesson No. 1	Introduction to Renewable Energy
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Objectives: By the end of this lecture, students will be able to:

- Identify, explain, and provide examples of both renewable and non renewable energy sources.
- Discover ways to conserve energy.
- Evaluate their families' use of energy.
- Understand the advantages and disadvantages of using renewable and non-renewable resources
- Contribution of renewable energy in agriculture

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 20GW 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.

Types of Energy

Basically energy can be classified into two types:

1. Potential Energy
2. Kinetic Energy

Potential Energy

Potential energy is stored energy and the energy of position (gravitational). It exists in various forms.

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Kinetic Energy

Kinetic energy is energy in motion- the motion of waves, electrons, atoms, molecules and substances. It exists in various forms.

Various Forms of Energy

Chemical Energy

Chemical energy is the energy stored in the bonds of atoms and molecules. Biomass, petroleum, natural gas, propane and coal are examples of stored chemical energy.

Nuclear Energy: Nuclear energy is the energy stored in the nucleus of an atom - the energy that holds the nucleus together. The nucleus of a uranium atom is an example of nuclear energy.

Stored Mechanical Energy: Stored mechanical energy is energy stored in objects by the application of a force. Compressed springs and stretched rubber bands are examples of stored mechanical energy.

Gravitational Energy: Gravitational energy is the energy of place or position. Water in a reservoir behind a hydropower dam is an example of gravitational energy. When the water is released to spin turbines, it becomes rotational energy.

Radiant Energy: Radiant energy is electromagnetic energy that travels in transverse waves. Radiant energy includes visible light, x-rays, gamma rays and radio waves. Solar energy is an example of radiant energy.

Thermal Energy: Thermal energy (or heat) is the internal energy in substances- the vibration and movement of atoms and molecules within substances. Geothermal energy is an example of thermal energy.

Electrical Energy: Electrical energy is the movement of electrons. Lightning and electricity are examples of electrical energy.

Motion: The movement of objects or substances from one place to another is motion. Wind and hydropower are examples of motion.

Sound: Sound is the movement of energy through substances in longitudinal (compression/rarefaction) waves.

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Light Energy: Light energy is a type of wave motion. That is, light is a form of energy caused by light waves. It enables us to see, as objects are only visible when they reflect light into our eyes

Classification of energy on the basis of source

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

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

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

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

2. Indirect sources of energy

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

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

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

Classification of energy on the basis of comparative economic value

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

1. Non-commercial energy: Each and every energy source has some economic value. Some energy sources are available comparatively at low cost whereas others are capital intensive. The energy sources, which are available cheaply, are called non-commercial sources of energy whereas the ones which are capital intensive are called commercial energy sources. Human labor and bullocks exemplify the category of non-commercial source of energy. One may argue that the unit energy available from animate sources is costlier than the mechanical energy. Therefore, animal sources of energy should be classified under the non-commercial. However, one should also bear in mind that human labour and animals are readily available and can be used as a sources of power directly, whereas in case of mechanical sources of energy, the machines (tractors, stationary engines, electric motors, etc. are very costly in terms of their purchase price and also often require a skilled operator.

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

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

Fundamentals of Renewable/Non Renewable Energy Sources

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

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

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

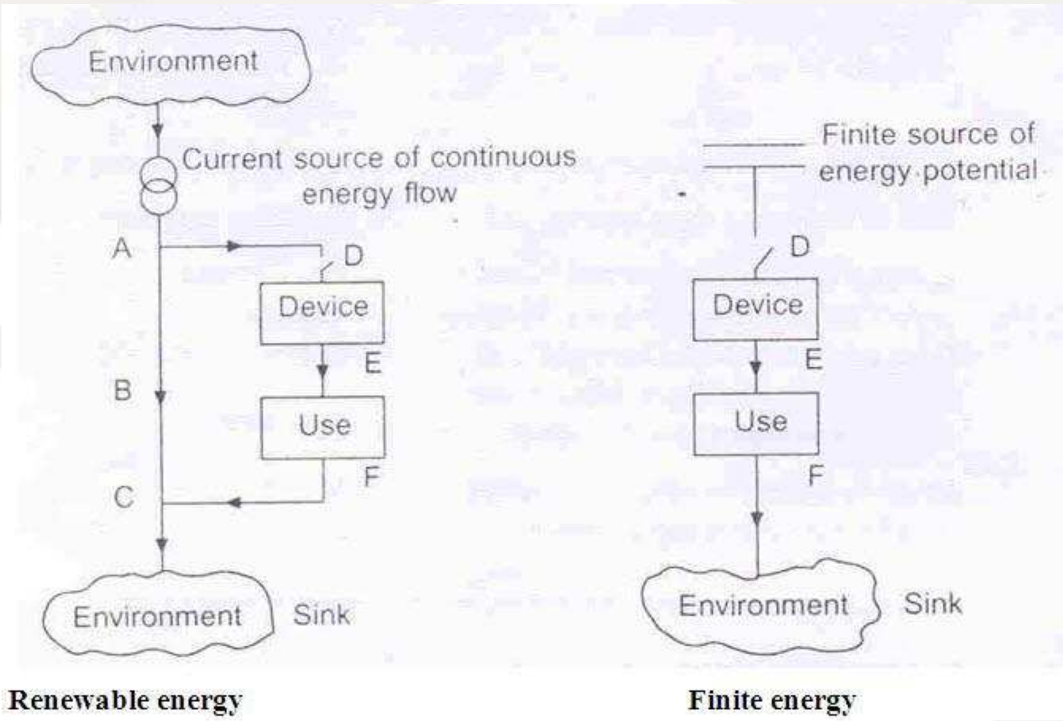

Figure 1: A comparison between renewable and nonrenewable energy system.

Why Renewable Energy?

Today we primarily use fossil fuels to heat and power our homes and fuel our cars. It's convenient to use coal, oil and natural gas for meeting our energy needs, but we have a limited supply of these fuels on the Earth. We're using them much more rapidly than they are being created. Eventually, they will run out. And because of safety concerns and waste disposal problems, the United States will retire much of its nuclear capacity by 2020. In the meantime, the nation's energy needs are expected to grow by 33 percent during the next 20 years. Renewable energy can help fill the gap.

Even if we had an unlimited supply of fossil fuels, using renewable energy is better for the environment. We often call renewable energy technologies "clean" or "green" because they produce few if any pollutants. Burning fossil fuels, however, sends greenhouse gases into the atmosphere, trapping the sun's heat and contributing to global warming. Climate scientists generally agree that the Earth's average temperature has risen in the past century. If this trend continues, sea levels will rise, and scientists predict that floods, heat waves, droughts, and other extreme weather conditions could occur more often.

Other pollutants are released into the air, soil and water when fossil fuels are burned. These pollutants take a dramatic toll on the environment and on humans. Air pollution contributes to diseases like asthma. Acid rain from sulfur dioxide and nitrogen oxides harms plants and fish. Nitrogen oxides also contribute to smog.

Renewable energy sources (wind, solar, small hydro, and biomass) are receiving increased attention in developed as well as developing countries and will also help us develop energy independence and security. Replacing some of our petroleum with fuels made from plant matter could save money and strengthen our energy security.

Renewable energy is plentiful, and the technologies are improving all the time. It provides long term sustainable development not only in

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agriculture but also in all other sectors. It requires implementation of renewable energy technologies that are more equitably distributed and environmental friendly. The cost of renewable energy technologies have declined significantly and further reduction of cost is also projected in the next few years.

1. Energy sources

Energy has been universally recognized as one of the most important inputs for economic growth and human development. Energy sources are mainly classified into two main groups, i.e. **renewable energies/ non-conventional and non-renewable/ conventional energies**. India, being a tropical country enjoys abundant sunshine. The country's topography also provides opportunities for using solar, wind and small hydro resources; and its vast land resources can sustain production of significant quantities of biomass, yet another form of renewable energy. Renewables have enormous potential to meet the growing energy requirement of increasing population of developing world, while offering sustainable solutions to the global threats of climate change (Yadav, 2014).

1.1. A renewable energy resource is one that can be renewed, or replenished in a reasonable amount of time (in years or a human-life span), once it has been used. Renewable energy is generated from natural sources (sun, wind, rain, tides, and vegetation) and can be generated again and again when needed. It is generally indigenous, non-polluting, virtually inexhaustibleand can be replenished naturally. For example, trees are a renewable resource because once a tree is removed and used; a new tree can grow in its place.

1.2. A non-renewable natural resource is one that has specific conditions that made them (like fuels of fossil origin such as coal, oil, natural gas, nuclear power, etc)through well-established technology and can take many generations to reproduce. Sometimes the conditions are not likely to occur again so they are limited in supply and once used cannot be re-generated within a short span of time. Non-renewable sources exist in the

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form of natural gas, oil and coal. For example, fossil fuels have been percolating beneath the Earth for hundreds of millions of years, and once they’re gone, they’re going to take millions more years to replenish.

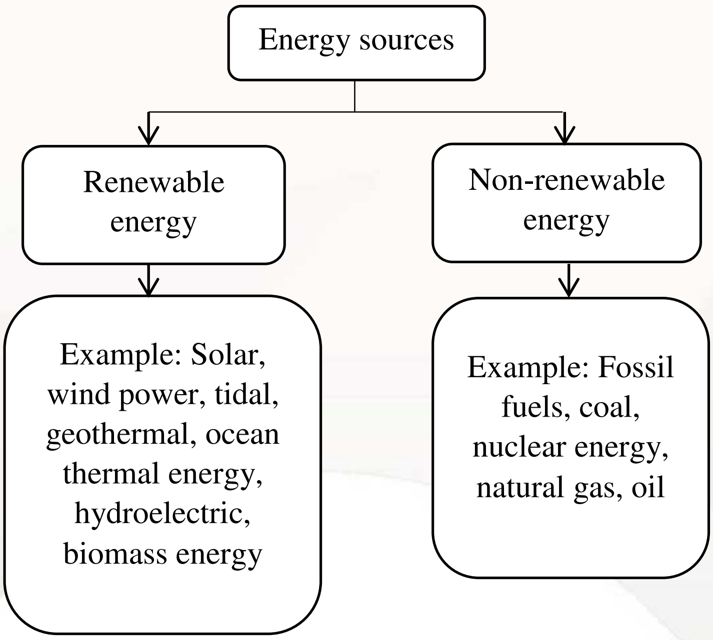

Fig. 2: Energy sources

New sources of energy: The new sources of energy are available for local exploitation. In many cases, autonomous and small power plants can be built to avoid transmission losses. Most prominent new sources of energy are tidal energy, ocean waves, OTEC, peat, tar sand, oil shales, coal tar, geo thermal energy, draught animals, agricultural residues etc., The total energy production in India is 14559×1015 joules. 93% of India’s requirement of commercial energy is being met by fossil fuels, with coal contributing 56%, and oil and natural gas contributing 37%. Waterpower and nuclear power contributing only 7% of total energy production.

Comparing the total energy production in India from commercial sources with that of world, it is only 3.5% of total world production.

2. Types of Renewable Natural Resources or Non-conventional energy sources

These are inexhaustible and are renewed by nature itself. Solar, wind, tidal, geo-thermal, hydro and biomass are examples of non-conventional energy sources.

2.1. Solar energy: The sun's light contains energy in the form of electromagnetic waves, Solar energy has the greatest potential of all the sources of renewable energy and if only a small amount of this form of energy could be used, it will be one of the most important supplied of energy specially when other sources in the country have depleted. Energy comes to the earth from the sun. this energy keeps the temperature of the earth above that in colder space, causes current in the atmosphere and in ocean, causes the water cycle and generate photosynthesis in plants. The solar power where sun hits atmosphere is 10^{17} watts, whereas the solar power on earth's surface is 10^{16} watts. The total world – wide power demand of all needs of civilization is 10^{13} watts. Therefore, the sun gives us 1000 times more power than we need. If we can use 5% of this energy, it will be 50 times what the world will require. The energy radiated by the sun on a bright sunny day is approximately 1 kW/m 2 , attempts have been made to make use of this energy in raising steam which may be used in driving the prime movers for the purpose of generation of electrical energy. However on account of large space required, uncertainty of availability of energy at constant rate, due to clouds, winds haze etc., there is limited application of this source in the generation of electric power. Now – a – days the drawbacks as pointed out that energy cannot be stored and it is a dilute form of energy, are out dated arguments, since the energy can be stored by producing hydrogen, or by storing in other mechanical or electrical devices, or it can be stored in containers of chemicals called eutectic or phase changing salts. These salts which store largequantities of heat in a relatively small volume, melt when they are heated and release heat later as they cool and crystallize. The energy can be concentrated in solar furnaces, for example which can achieve temperatures in the region of 5000 0C. the facts speak in favour of solar energy, as we have seen in analysis of commercial energy sources, that world's reserves of coal, oil and gas will be exhausted within a few decades. Nuclear energy involve considerable hazards and nuclear fusion has not yet overcome all the problems of even fundamental research, compared with these technologies, the feasibility of which is still uncertain and contested, the technical utilization of solar energy can prove very useful. Utilization of solar energy is of great importance to India since it lies in a temperature climate of the region of the world where sun light is abundant for a major part of the year.

The applications of solar energy which are enjoying most success to-day are:

1. Heating and cooling of residential building.
2. Solar water heating.
3. Solar drying of agricultural and animal products.
4. Solar distillation on a small community scale.
5. Salt production by evaporation of seawater or inland brines.
6. Solar cookers.
7. Solar engines for water pumping.
8. Food refrigeration.
9. Bio conversion and wind energy, which are indirect source of solar energy.
10. Solar furnaces.
11. Solar electric power generation by

i. Solar ponds.
ii. Steam generators heated by rotating reflectors (heliostat mirrors), or by tower concept.
iii. Reflectors with lenses and pipes for fluid circulation (cylindrical parabolic reflectors).

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12. Solar photovoltaic cells, which can be used for conversion of solar energy directly into electricity or for water pumping in rural agricultural purposes

Modern residential solar power systems use photovoltaic (PV) to collect the sun's energy. "Photo" means "produced by light," and "voltaic" is "electricity produced by a chemical reaction." PV cells use solar energy to generate a chemical reaction that produces electricity. Each cell contains a semiconductor; most commonly silicon in one of several forms (single-crystalline, multi-crystalline, or thin-layer), with impurities (either boron or phosphorus) diffused throughout, and is covered with a silk screen. Cells are joined together by a circuit and frame into a module. Semiconductors allow the electrons freed from impurities by the sun's rays to move rapidly and into the circuit, generating electricity. Commercial residential PV modules range in power output from 10 watts to 300 watts, in a direct current. A PV module must have an inverter to change the DC electricity into alternating current energy in order to be usable by electrical devices and compatible with the electric grid. PV modules can also be used en masse to create large-scale power plants.

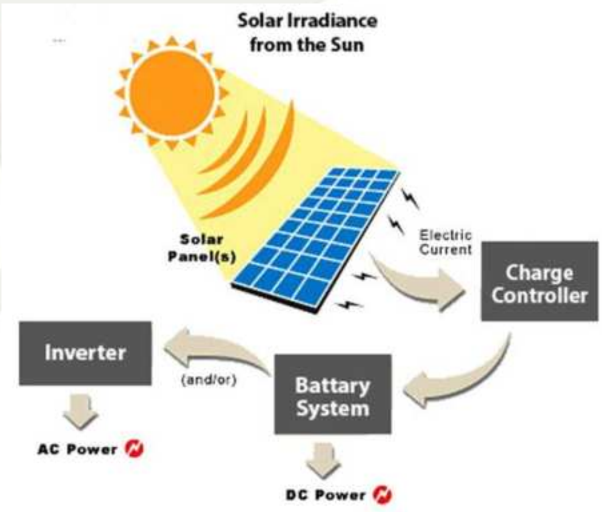

Fig.2 . Solar energy working system

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Using PV modules to generate electricity can significantly reduce pollution. The most energy used in creating solar panels is used to purify and crystallize the semiconductor material. No official numbers are available on the exact amount of energy used to create solar panels because there is no industry standard for making the crystals. A number of researchers have done work in attempt to address concerns about energy payback for PV systems.

2.2. Wind energy:

Wind energy is one of the most promising alternative energy technologies of the future. Throughout recent years, the amount of energy produced by wind-driven turbines has increased exponentially due to significant breakthroughs in turbine technologies, making wind power economically compatible with conventional sources of energy. Wind energy is a clean and renewable source of power. The use of windmills to generate energy has been utilized as early as 5000 B.C., but the development of wind energy to produce electricity was sparked by the industrialization. The new windmills, also known as wind turbines, appeared in Denmark as early as 1890. The popularity of wind energy however has always depended on the price of fossil fuels. For example, after World War II, when oil prices were low, there was hardly any interest in wind power. However, when the oil prices increased dramatically in the 1970s, so did worldwide interest in the development of commercial use of electrical wind turbines. Today, the wind-generated electricity is very close in cost to the power from conventional utility generation in some locations.

Where does wind come from? Wind is a form of solar energy and is caused by the uneven heating of the atmosphere by the Sun, the irregularities of the Earth’s surface, and rotation of the Earth. The amount and speed of wind depends on the Earth’s terrain and other factors. The wind turbines use the kinetic energy of the wind and convert that energy into mechanical energy, which in turn can be converted into electricity by means of a generator (Fig)

There are essentially two types of wind turbines: The horizontal-axis variety, and the vertical-axis design. The horizontal-axis design is used more commonly and looks like an Old Dutch windmill, whereas the vertical-axis design looks like and eggbeater. These wind turbines generally have either two or three blades, called rotors, which are angled at a pitch to maximize the rotation of the rotors. The horizontal-axis design is slightly more efficient and dependable than the vertical-axis windmill. Most of the windmill models that are currently in production are thus horizontal-axis windmills.

Utility scale turbines can produce anywhere from 50 kilowatts to several megawatts of energy. These large windmills are generally grouped together in a windy area in what is called a wind farm. The proximity of the windmills in a wind farm makes it easier to feed the produced electricity into the power grid. Wind energy offers many advantages compared to fossil based power and even some other types of alternative energy, which explains why it is the fastest growing energy source in the world. The two main reasons are cleanliness and abundance. The fact that wind is a renewable resource gives it a major advantage over oil and the nonrenewable resources. Considering that environmental pollution is being linked to several global problems that might eventually threaten the existence or at the very least worsen human living conditions, the fact that windmills do not produce any emissions whatsoever is another reason to increase the use of wind turbines. Increasing the percentage of wind power used by the United States would not be unreasonable, seeing that the price of wind power is between 4 and 6 cents.

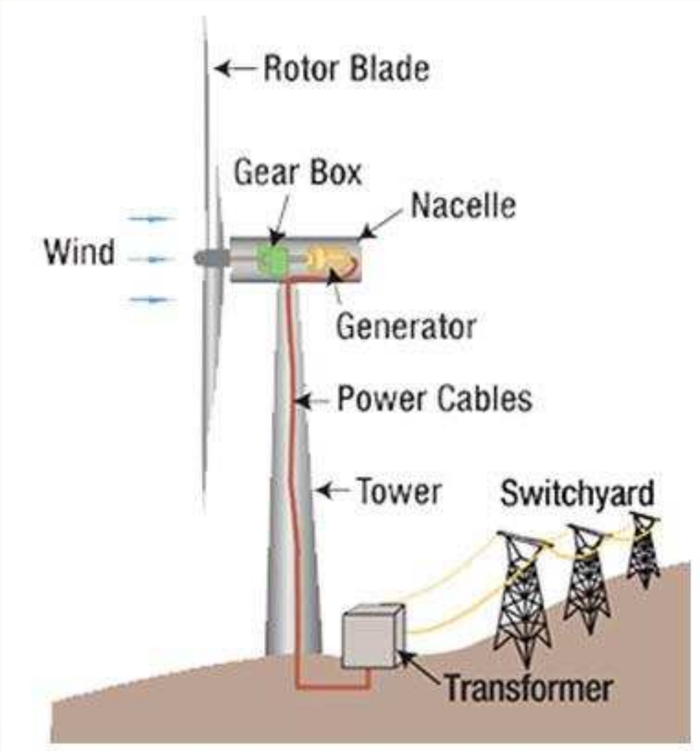

Fig.3 Working of wind turbine

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Even though wind energy has many environmental and supply advantages, there are several disadvantages that limit the usability of wind power. The main disadvantage to wind power is that it is unreliable. Wind does not blow at a constant rate, and it does not always blow when energy is needed. Furthermore, the windiest locations are often in remote locations, far away from big cities where the electricity is needed. Just like with any other energy plant, people oppose it because of aesthetic reasons. The rotor noise produced by the rotor blades is another reason for opposition.

Wind seems to be a very good source of alternative energy. Its biggest setback is its unreliability, but in combination with other, more reliable sources, wind energy should be used extensively to supplement the demand for energy.

2.3. Hydroelectric Power Hydropower is America's leading renewable energy resource. This notable success can be attributed to the fact that out of all the renewable power sources, hydropower the most reliable, efficient, and economical. Furthermore, the concept behind hydroelectric power is fairly simple and has been in use for a significant span of time.

The earliest reference to the use of the energy of falling water is found in the work of the Greek poet Antipater in the 4th century BC. Indeed, the word “hydro” comes from the Greek language meaning “water.” Several centuries later, the Romans were the first to utilize the waterwheel. Due to the Romans’ powerful influence on Europe through conquest, the waterwheel was soon commonly found throughout that continent, and by 1800, tens of thousands of waterwheels had been built. These early waterwheels were of course not used for power generation, but mostly for grinding crops. Water energy was first converted into electricity on Sept. 30, 1882 near Appleton, Wisconsin.8 By 1980 hydroelectric power accounted for about 25% of global electricity and 5% of total world energy use, which amounted to approximately 2,044 billion kilowatt hours (kW h).

Harvesting energy from water is possible due to the gravitational potential energy stored in water. As water flows from a high potential energy (high ground) to lower potential energy (lower ground), the potential energy difference thereby created can be partially converted into kinetic, and in this case electric, energy through the use of a generator. There are essentially two major designs in use that utilize water to produce electricity: the hydroelectric dam, and the pumped-storage plant. The waterwheel discussed at the beginning of this paper is currently no longer in use and has been replaced by the far more economical and efficient dam. Both the waterwheel and the dam work on the same general principle, but the dam has the advantage of being more reliable due to the reservoir behind it. The principle is simple: the force of the water being released from the reservoir through the penstock of the dam spins the blades of a turbine. The turbine is connected to the generator that produces electricity. After passing through the turbine, the water reenters the river on the downstream side of the dam. A pumped-storage plant is very similar to the hydroelectric dam, the main difference being that the pumped-storage plant uses two reservoirs, one being considerably higher than the other. The advantage of this design is that during periods of low demand for electricity, such as nights and weekends, energy is stored by reversing the turbines and pumping water from the lower to the upper reservoir. The stored water can later be released to turn the turbines and generate electricity as it flows back into the lower reservoir. Now that the two types of facilities have been discussed, there are also two way of obtaining the water: dam and run-of-the-river. A dam raises the water level of a stream or river to an elevation needed to create the necessary water pressure. In a run-of-the river scenario, the water is diverted from its natural path, enters the turbine, and is later returned to the river. Hydroelectric power offers several significant advantages compared to fossil based power, and even other types of alternative energy. Probably the most important asset of hydroelectric power is its reliability. Furthermore, it creates no pollution, and once the dam is built, even though that process is very expensive, the produced energy is virtually free. A dam has the ability to continuously produce electricity and can adjust to peaks in demand by storing water above the dam and by being able to increase production to full capacity very quickly. Other than the high construction and planning costs, the major drawbacks of large dams are mostly environmental. The dam does not produce harmful emissions as in the case of fossil fuel burning. It does however alter the landscape dramatically, producing several severe, even unbearable changes to the habitat of fish and other plants and animals. Building a large dam will of course flood a large area of land upstream of the dam, causing problems for the animals that used to live there. It furthermore affects the water quantity and quality downstream of the dam which in turn affects plants and animals. Blocking the river also disallows certain migration pattern of fish. Finding sites that are suitable for dams is also a challenge. This is one of the reasons why the hydroelectric power production in the U.S. cannot increase by much in the future: most of the suitable locations have already been utilized. According to the Energy Information Administration, the total amount of electricity produced in the U.S. through hydroelectric means has increased by 6.3% from 2004 to 2005. Even though U.S. construction of dams has peaked and is decreasing, advances in turbine technology maintain a slight growth margin of electricity production. Precipitation however also influences the ability of dams to produce electricity. In this sense, 2005 could have been a year of increased precipitation if compared to 2004. Overall, hydroelectric power seems to be a very good source of alternative energy: one that should be maintained at the maximum level possible. It has the main advantage over all the other forms of alternative energy production in that it is reliable, whereas the other forms of alternative energy are not. The main disadvantage is that hydroelectric energy production in the U.S. is currently being used to its maximum potential, which means that large sums of investment will produce only small increases productivity. Other alternative energy sources are not yet as developed and hence will produce greater advances in productivity with the same or even a smaller input of money. Hydroelectric spending should be maintained at current levels, and more money should be invested in the other sources of alternative energy.

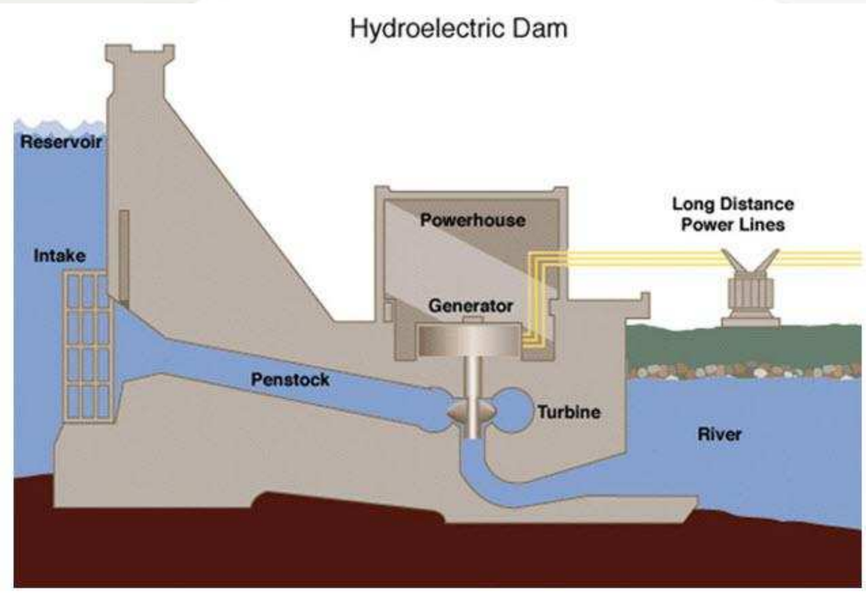

Fig. 4. Hydroelectric power plant layout

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2.4. Geothermal energy

Geothermal energy is one of the only renewable energy sources not dependent on the Sun. Instead, it relies on heat produced under the surface of the Earth. Geothermal energy already has several applications and could potentially provide a significant source of renewable power for the United States. However, it is limited by a multitude of factors revolving around the issues of sustainability and economics. There are two main applications of geothermal energy, which include producing electricity at specialized power plants, and direct-heating, which puts to direct use the temperature of water piped under the earth's surface. Geothermal power plants take on several types of forms, depending on the type of geothermal area from which they extract energy. In any case, the plants depend on steam to power turbines and generate electricity, though the methods of producing steam varies depending on the type of geothermal reservoir.12 Direct-heating, on the other hand, provides immediate, usable energy. This type of energy can heat individual buildings or entire areas, as in the city of Klamath Falls, Oregon. It can also cool buildings by pumping water underground where the temperature remains relatively stable near 60 degrees Fahrenheit, and then into buildings, where the water absorbs heat, thus helping to air condition the building. The United States also uses direct heating in fish farms, spas, and greenhouses. Geothermal energy could potentially become a major source of renewable power for the United States. This is because geothermal energy reduces the United States dependence on foreign oil, it's extremely reliable due to the constant source of heat emanating from the earth, and it has almost no negative environmental impact.15 In 2004, the US produced approximately 2300 MW of electricity, and the Department of Energy estimates that the figure could reach 15000 MW per year within a decade.16 In the grander scheme, however, geothermal energy accounted for only about 0.34% of total U.S. energy consumption, and 5.56% of renewable energy consumption.17 But more energy could be extracted using developing technology, which doesn't rely on existing hot water and

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steam reservoirs. The process involves drilling deep into the surface of the Earth where temperatures are hot, and then injecting water into cracks of rock, which is heated and then pumped back to the surface.18 If this "hot dry rock" (HDR) technology proves effective, then more geothermal plants could operate in more locations, since much of the Earth's surface is underlain by hot, dry rock. Some problems that geothermal energy faces are depletion of both water and heat in geothermal areas. The first problem has been partially addressed by re-injecting water into reservoirs, thus sustaining the plant's ability to operate. However, it has been shown that water re-injection can cause small earthquakes, which raises the question of whether the plants should be liable for the damages caused.19 In Alameda, California, water reinjection at a geothermal power plant triggered earthquakes of magnitudes up to 3.9 and 3.5 on the Richter scale, which were felt 90 miles away in the community of Middletown.

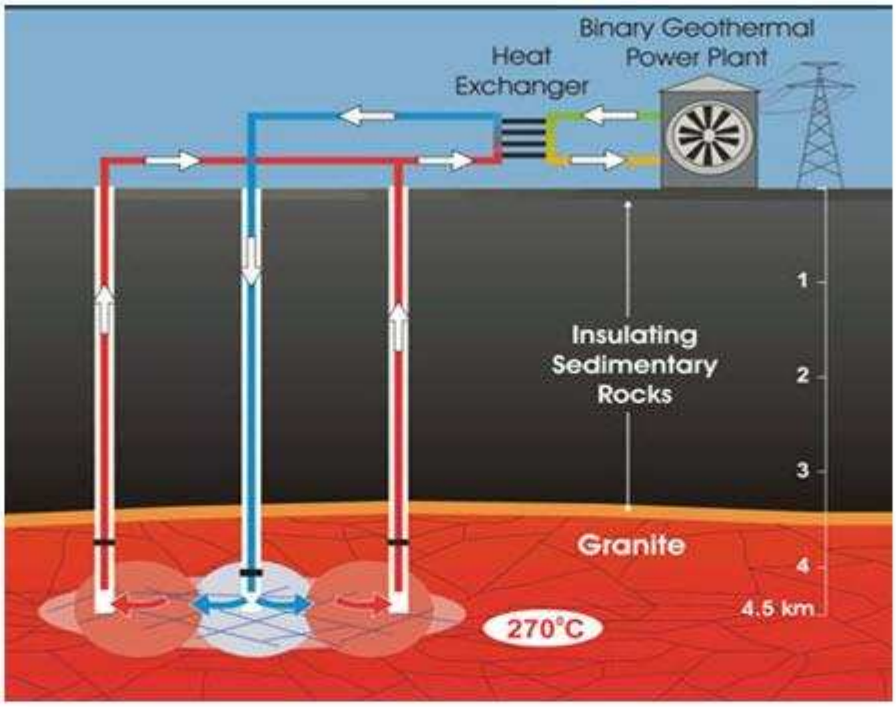

Fig. 5. Geo-thermal power plant

(source:

http://ecoursesonline.iasri.res.in/mod/page/view.php?id=128399)

As of now, there is no government regulation concerning the repayment of damages caused by these earthquakes, though community groups such as the one in Middletown have pressured the plant to compensate homeowners for damages such as cracked chimneys, which can cost about $10,000 to fix.20 Heat depletion of geothermal areas is more problematic than water depletion in the long run, since it cannot be avoided. It is caused by a natural cooling-off of the earth's crust, and in these cases, plants would become less and less efficient over several decades until they were rendered useless. Other issues facing geothermal power in the United States are building costs and economic competitiveness with other energy sources. Geothermal plants can be expensive, depending on factors such as how deep the wells must be drilled and the temperature of the water or steam. These initial costs of an economically competitive plant can be as high as $2800 per kW installed capacity, which accounts for about two thirds of total costs for the plant. The plants are economically competitive in the long run however, because their fuel is free, whereas natural gas or coal plants spend up to two thirds of their total operating costs on fuel. Another problem that adds cost to geothermal plants is the problem of connecting to energy grids. This is a critical issue because geothermal plants are built where geothermal resources permit- such as geysers and areas with less-heated water. Over time, however, the plants pay for themselves and all the necessary costs because of low operating costs; namely, the fact that the plants energy is free and always available. The National Commission on Energy Policy believes geothermal energy can cost from 4-6 cents per kWh, which depends on the construction of new geothermal plants, but compares favorably with other renewable energies such as solar power, which costs 20-25 cents per kWh.22 It's also competitive with coal and natural gas, which costs about 4-5 cents per kWh.23 The projected low cost therefore depends on the availability and exploitation of existing geothermal resource Because of its reliability, accessibility, low impact on the environment, and potential low cost, geothermal energy is a very attractive source of renewable energy for the United States. Expanding use of geothermal energy depends largely upon the success of the hot dry rock technology and the simultaneous

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prevention of earthquakes caused by water injection at those plants and water re-injection at other plants. If the HDR technology proves to be viable and safe, geothermal plants can be built in closer proximity to electricity grids, without worrying about geothermal resources like geysers. This would make the plants more cost effective and enable geothermal energy to compete with other energy types.

2.5. Ocean thermal energy: Ocean thermal energy conversion system (OTEC) use the temperature difference of seawater at different depths to generate electricity. It utilizes the temperature difference that exists between the surface waters heated by the sun and the colder deep (up to 1000 m) waters to run a heat engine. Such a small temperature difference makes energy extraction difficult and expensive. Hence, typically OTEC systems have an overall efficiency of only 1-3 %.

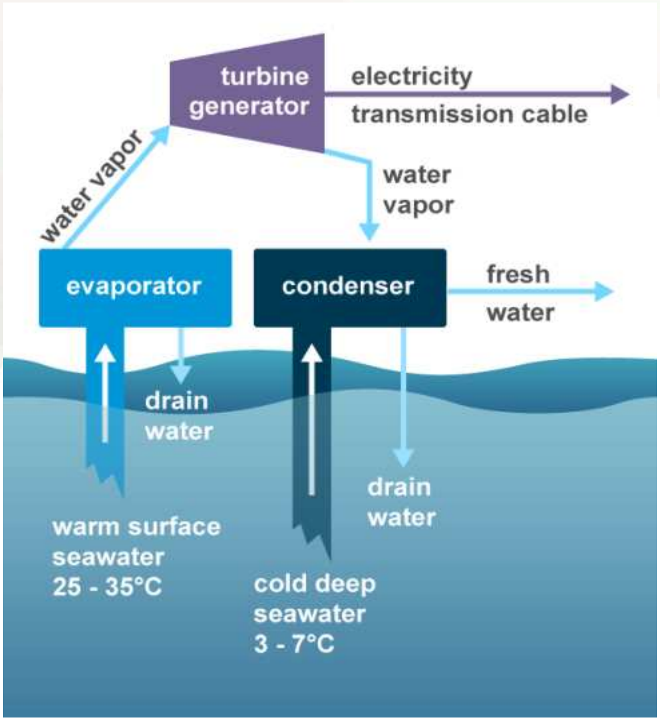

Fig. 6. Ocean thermal energy conversion system

(Source:https://www.eia.gov/energyexplained/hydropower/ocean-thermal-energy-conversion.php)

The Ocean can produce two types of energy: thermal energy from the sun's heat, and mechanical energy from the tides and waves. Ocean thermal energy can be used formany applications, including electricity generation. Electricity conversion systemsuse either the warm surface water or boilthe seawater to turn a turbine, which activatesa generator.

The electricity conversionof both tidaland wave energy usually involvesmechanical devices. Adam is typicallyused to convert tidal energy into electricity by forcing the water through turbines,activating a generator. Meanwhile, waveenergy uses mechanical power to directlyactivate a generator, or to transfer to aworking fluid, water, or air, which thendrives a turbine/generator.

2.6. Biomass energy:

As a pending global energy crisis appears more and more imminent, it is important to consider many different options for new energy sources. Renewable energy sources are ideal because they are more efficient, environmentally friendly and, ultimately, better for consumers. Biomass can be converted into fuels through a number of different processes, including solid fuel combustion, digestion, pyrolysis, and fermentation and catalyzed reactions. Electricity is generated in many places through solid fuel combustion. The majority of America's electricity is fueled by coal combustion. However, many states, especially California, are encouraging companies to use biomass fuels to generate electricity. These products are usually wood matter, vegetation, waste from lumber yards, and the like.25 Power plants burn such fuels to heat a boiler, and the resulting steam powers turbines & generators.26 This process still releases a lot of carbon dioxide and other polluting gases into the environment, but helps eliminate waste efficiently.

Digestion is another process that makes use of existing waste. The term is a misnomer. Digestion is the naturally occurring process of bacteria feeding on decaying matter and making it decompose. It is that which releases gases like methane, hydrogen, carbon monoxide, etc.27 In many landfills, owners are experimenting with set-ups to best collect the gases produced by such bacteria. The standard system includes pipelines running through the waste to collect the gases. Animal feed lots and other facilities are also exploring tapping such resources. A zoo in upstate New York is using their elephant manure to do the same thing. Benefits of this process include the relative lack of impurities in the gases produced and the fact that the synthesis gases (carbon monoxide and hydrogen) can be converted to any kind of hydrocarbon fuel.

A third process, pyrolysis, creates a product much like charcoal, with double the energy density of the original biomass, making the fuel highly transportable and more efficient. Anhydrous pyrolysis heats the biomass at intense temperatures in the absence of oxygen or water. Scientists assume that this is the process that originally produced fossil fuels (under different conditions). Most industrial processes of pyrolysis convert the biomass under pressure and at temperatures above 800° F (430° C). A liquid fuel can also be produced using this process.

The most widely used alternative fuel, ethanol, is created through fermentation of organic materials. Ethanol has a current capacity of 1.8 billion gallons per year, based on starch crops such as corn. Again, the fuel conversion process takes advantage of a natural process. Microorganisms, especially bacteria and yeasts, ferment starchy, sugary biomass products (like corn), yielding products like ethanol, which can be used as fuels in a variety of applications. Biodiesel is an increasingly popular fuel, especially in the transportation sector. This mono-alkyl ester is formed by combining fuel-grade oil, processed from sources like vegetable oil, animal fats, algae and even used cooking grease, with an alcohol (like methanol or ethanol), using a catalyst. It shows great promise as both a neat fuel (used alone) and as an additive to petroleum diesel.

Using biomass could be the answer to the energy questions made more imminent by the recent crises that have further threatened our oil supply. The current technologies take advantage of many natural, long-utilized

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processes in order to create "new" kinds of fuel. Upon further observation, one realizes that these fuels are very basic, using the most readily available energy sources with very simple, standardized processes that greatly reduce pollution and offer hope for the future.

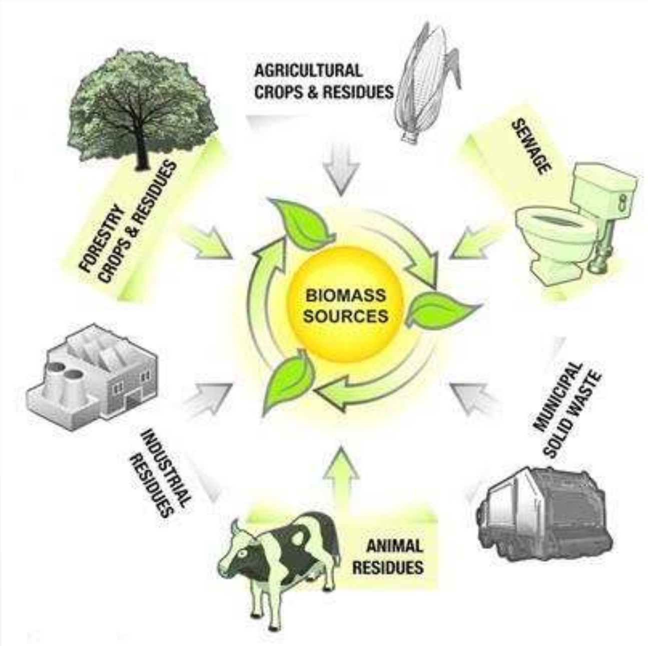

Fig. 7. Biomass conversion

(Source: http://www.gemcopelletmill.com/blog/biomass-energy-in-canada.html)

Ethanol

Fuel-quality ethanol is beneficial for car-owners, the economy and the environment. This growing technology is looking to be an immediate part of the solution to the forthcoming energy crisis. Ethanol, also known as ethyl alcohol or grain alcohol, is a colorless, clear liquid.The chemical formula is CH_3CH_2OH. Fuel-quality ethanol goes through more processes than do alcoholic beverages, in order to make it unfit for human consumption and to increase the purity so as to avoid separation when mixed with gasoline. The most common method for making ethanol used in the United States is the dry-mill method. At the beginning of 2005, the 81 ethanol plants in 20 states can produce up to 4.4 billion gallons each year, and the 16 plants under construction are expected to add 750 million gallons of capacity. The dry mill process has advanced to the point at which any cellulosic (plant fiber) biomass can be used to make fuel ethanol (and is now being referred to as the Advanced Bioethanol Technology). The variety of feedstock that can be used today includes corn, barley, wheat, cornstalks, rice straw, sugar cane bagasse, pulpwood, switch grass and even municipal solid waste, offering tremendous opportunities for new jobs and economic growth.

Ethanol is not used by itself to fuel cars. Instead, it’s mixed with gasoline. The two most common blends are E10 and E85. The number refers to the percentage of ethanol in the blend. E10 is a blend of ten percent ethanol and ninety percent gasoline. E85, the most mainstream alternative fuel, is eighty-five percent ethanol and fifteen percent gasoline. Using ethanol increases the octane rating and decreases the amount of damaging emissions associated with fuel consumption. It is for this second reason that ethanol use is so strongly recommended and endorsed by state and federal governments. The Clean Air Acts Amendments of 1990 require using reformulated gasoline (RFG) to reduce emissions in major metropolitan areas. RFG blends gasoline with oxygenates, of which ethanol is increasingly popular. Methyl tertiary-butyl ether (MTBE) used to be the most popular, but there are increasing environmental health concerns, regarding seepage, surrounding its use. Oxygenates (compounds with structures similar to that of gasoline, but with the addition of oxygen) dilute the noxious, dangerous gases emitted by gasoline consumption, including nitrogenous oxides, volatile organic compounds and other toxic like carbon monoxide. It is for this reason that the Clean Air Acts Amendments require inclusion of oxygenates like ethanol in the fuel supplies of metropolitan areas, and that the government offers many incentives. These include the Clean Fuel Tax Deduction, taken off the vehicle property tax on new qualified clean fuel vehicles or the conversion of vehicles to run on alternative fuels; the ethanol and biodiesel tax credit, under the American Jobs Creation Act of 2004 (Public Law 108-357); the credit for installation of alternative fueling stations, under the Energy Bill

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of 2005; the new Flexible Fuel Vehicle labeling requirement, and many more. Approximately one-third of the states offer incentives as well.

Increase in use of ethanol as fuel will benefit farmers economically. The majority of ethanol used today comes from corn, and it is the farmer-owned ethanol plants that are driving the industry’s growth. Half of the operating plants are owned by farmers and local investors. The United States Department of Agriculture estimates that the Renewable Fuels Standard would increase the demand for corn for ethanol to 2 billion bushels each year by 2012, almost double the current demand, which would raise net farm income to $4 billion.

There are drawbacks to using ethanol. The presence of oxygen and smaller molecules means it produces less energy than raw gas, reducing fuel economy by 2 to 3 percent. The octane boost from ethanol is smaller than that of MTBE, and ethanol raises gasoline’s volatility, increasing evaporative emissions, all of which are of concern. However, these shortcomings pale in comparison to the health concerns and need to reduce the use of gasoline consumption. There is a reason ethanol blend is required in fuel by Minnesota state law. The environmental and economic benefits make it a desirable alternative. As technology improves, more of the drawbacks will be decreased, and ethanol and other alternative fuels will become mainstream and standard-issue, leading the United States away from our gasoline addiction.

2.7. Tidal energy: The periodic rise and fall of water level of sea, which is caused by the action of the sun and moon on water of the earth is called “tide”. A barrage is a barrier constructed across the sea to create a basin for storing water. During high tide, water flows from sea to tidal basin through turbine, thus producing electricity. During low tide, water flows from tidal basin to sea through turbine again producing electricity.

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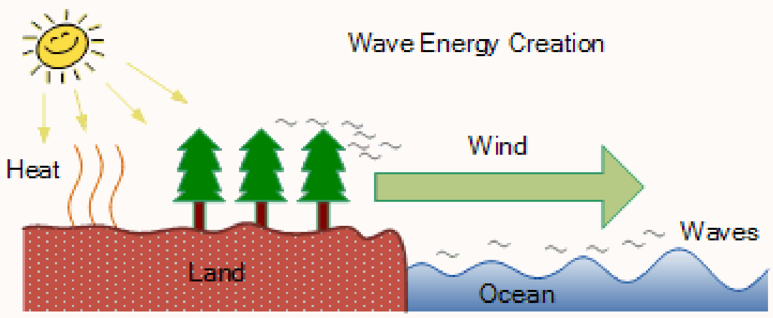

Fig. 8. Wave energy creation

(Source: https://www.alternative-energy-tutorials.com/energy-articles/wave-energy-devices-how-wave-energy-works.html)

3. Types of Non-renewable Natural Resources or Conventional Energies

Non-renewable energy is a source of energy that will eventually run out. There are four major types of non-renewable resources: **oil**, **natural gas**, **coal**, and **nuclear energy**. **Oil**, **natural gas** and **coal** are collectively called **fossil fuels**.

3.1. Oil energy: Crude Oil is referred to as Liquid Petroleum. It is used for gasoline; heating oil and diesel fuel. These are inflammable liquids composed primarily of hydrocarbons (90-98 %) and the rest are organic compounds containing oxygen, nitrogen, sulphur and traces of organo-metallic compounds. Depending on the crude oil composition and demand, refineries produce different petroleum products. Crude petroleum is refined by the process of fractional distillation to obtain more useful products. These are heated in a furnace up to a temperature of about 44 °C and vapours thus formed are passed to a fractioning column. The vapours are cooled gradually in the column and different fractions are obtained.

3.2. Natural gas energy: Natural gas reserves often share space with underground oil reserves, so the two non-renewable resources are often extracted at the same time. Consumers use it as cooking fuel, to heat houses, and sometimes as vehicle fuel.

3.3. Coal: Coal is considered as the backbone of energy sector for its use in industry, transportation and electric power generation. Coal is classified into three major types, namely anthracite, bituminous and lignite. Anthracite is the oldest coal from geological perspective. It is a hard coal composed mainly of carbon with little volatile content and practically no moisture. Lignite is the youngest coal from geological perspective. It is a soft coal composed mainly of volatile matter and moisture content with low fixed carbon. Calorific value of Indian coal ranges from 16 to 19 MJ/kg. Indian coals contain 40-42 % carbon and the rest consist of minerals, hydrogen, oxygen, nitrogen and sulphur. Hence these coals have high ash content.

3.4. Nuclear Energy: Nuclear energy makes use of Uranium-235, a radioactive chemical naturally found in theearth. This radioactive substance undergoes decay and in the process releases a great deal of heat. The heat is then used to create steam; that steam is used to turn a turbine in a generator. The generator produces theelectricity. There are no greenhouse gases released in this process. However, there are radioactivebyproducts that must be stored safely because they are an environmental hazard. It is considered as non-renewable form of energy because it takes real manipulation to split an atom

Energy Scenario in India

Energy-use Statistics: Currently, India is the sixth largest energy consumer in the world and the country's energy consumption is expected to increase in the near future. In the past, India has derived most of its energy from coal, but recently the country has been making efforts to extract energy from other sources. However, fossil fuels still remain the largest energy source. About 76% of India's electricity is produced in power plants using coal or petroleum products (Buran et al., 2003), of the remainder, 22% is hydroelectric and 2% is nuclear. According to data from India's Ministry of Statistics and Programme Implementation, the nation's total energy consumption has increased approximately fourfold over the last three decades. In 1999, India had an electricity consumption total of approximately 4.24 x 1011 KWh (Anon, 2001).

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

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

Pollution Statistics: India emits the fifth most carbon of any country in the world: at 253 million metric tons, only the United States, China, Russia and Japan surpassed its 1998 level of carbon emissions. The carbon emissions have grown ninefold over the past 40 years and are forecasted to grow 3.2% per year until 2020, and are faster than both China and the United States. The Indian Government estimates the cost of environmental degradation in recent years to be 4.5% of GDP. Low energy-efficiency of coal-burning power plant is a contributing factor. India's coal plants are old and are not equipped with the most modern pollution controls. With the shortage of generating capacity and scarcity of public funds, old coal-fired plants will likely remain in operation for some time. Power plant modernization, improvements in transmission to cut distribution losses and legislation to encourage end-user energy conservation are all part of the Government's current energy efficiency efforts. Emerging industrial

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centers and the lack of pollution-control mechanisms have resulted in a severe drop in air quality in India. Of the 3 million premature deaths in the world that occur annually due to air pollution, more than 5,00,000 occur in India (Anon, 2000). According to the World Health Organization, the city of New Delhi is one of the ten most polluted cities in the world (Michaels, 2001).

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

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

Renewable Energy Potential in India:

Renewable Energy Programme

The relevance of the increasing use of renewable energy sources in the transition to a sustainable energy base was recognised in India even in the early 1970s. Since the early 1980s, a significant thrust has been given to the development, trial and induction of a variety of renewable energy technologies for use in different sectors. To begin with, the endeavours were steered and overseen by the Commission for Additional Sources of Energy (CASE) set up in 1981. In 1982, a separate Department of Non-Conventional Energy Sources (DNES) was created in the Ministry of Energy and was entrusted with the charge of promoting non-conventional energy sources. A decade later, this was upgraded and thus MNES (Ministry of Non-Conventional Energy Sources) started funding as a separate Ministry from 1992 to develop all areas of renewable energy.

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

Importance of Renewable Energy Resources and Technologies for Sustainable Development

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

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

- ✓ Renewable energy sources cannot be depleted unlike fossil fuel and uranium resources. If used wisely in appropriate and efficient applications, they can provide a reliable and sustainable supply energy almost indefinitely. In contrast, fossil fuel and nuclear energy sources are finite and can be diminished by extraction and consumption,
- ✓ They favour power system decentralization and locally applicable solutions more or less: independent of the national network, thus enhancing the flexibility of the system and the economic power supply to small isolated settlements. That is why, many different renewable energy technologies are potentially available for use in urban areas.

Essential Factors for Sustainable Developments

The main concept of sustainability, which often inspires local and national authorities to incorporate environmental considerations in setting energy programme, though being given many different meanings in different contexts, embodies a long-term perspectives. Besides, the future energy system will be largely shaped by broad and powerful trends that have their roots in basic human needs. In conjunction with this, the increasing world population requires the definition and successful implementation of sustainable development. There are various essential parameters that can help in achieving a successful sustainable development in a society. Such parameters can be described as follows:

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

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

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

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

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

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

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

Contribution of Renewable Energy in Agriculture Sector

Harnessing renewable energy systems in agriculture is termed **clean/green energy farming** because switching from fossil fuel burning for energy production to renewable energy sources lowers the total amount of carbon releasedinto the atmosphere as CO_2 gas.In combination with energy conservation practices, farmers canproduce their own energy to become even more self-sufficient by reducing external inputs. Notonly does renewable energy help the farmer save money, it also combats the effects of globalwarming. Renewable energy also includes generation of power to do a number of farm tasks: pumping water for irrigation, for livestock or for domestic use; lighting farm buildings; powering processing operations and others. These forms of renewable energy include solar energy, wind and water power, oil from plants, wood from sustainable sources, other forms of biomass (plant material), and biogas (gas produced from fermentation of manure and crop residues) (Aliet al., 2012)

Table 1: Renewable Forms of Energy (Source: Ogunladeet al., 2018)

Energy Source	Description	End Product
Biomass	Burning of plant materials and animal wastes	Heat and gas
Hydropower	Water owing from higher to lower Electricity elevations through dams	Electricity
Wind	Capture of wind by turbines	Electricity
Geothermal	Capping stream and hot water from the earth's mantle	Heat and Electricity
Solar	Absorbing and storing heat from the sun	Heat and Electricity
Emerging Technologies		
Hydrogen fuel	Burning hydrogen gas	Power for movement
Nanotechnology	Using the unique properties of materials on the size , scale of molecules or atoms	Electricity
Ancient Technologies		
Water	Water wheels, dams, weight	Power, motion
Wind	Windmills, sails	Power, motion
Movement (kinetic energy)	Animals, Human exertion	Power, motion

Renewable technologies may be either modern advance in energy generation or ancienttechnologies that some parts of the world continue to use. Many renewable energy sources do notproduce usable energy directly; additional equipment may be required to convert one type ofenergy into another form.

4.1. Solar Energy: Widespread use of solar energy for domestic, agricultural and agro-industrial activities has been practiced almost since the development of civilization. Increasing threat of acute shortage of the commercial sources of energy coupled with serious environmental pollution problems has accelerated interest in the scientific exploitation of renewable sources of energy. Energy available from the sun is inexhaustible and environment friendly. Therefore, the solar energy technologies are likely to play an important role in the near future through a variety of thermal applications and decentralized power generation and distribution systems. The power from the sun intercepted by the earth is approximately 1.8 x lO^{ll} MW. This makes it one of the most promising unconventional energy sources. Solar energy is available in abundance in most part of our country throughout the year. In India,' the annual average daily solar radiation received over the whole of the country is around 1800 J/cm^2/day. Drying of various agricultural produce in open sunlight is an age-old practice. Development of various solardevices for thermal applications such as water heating and space heating, drying, cooking and power generation began during the most centuries.

4.2. Wind Energy: Farmers and ranchers are in a unique position to benefit from the growth in the wind industry. To tap this market, farmers can lease land to wind developers, use the wind to generate power for their farms, or become wind power producers themselves. Farmers and ranchers can generate their own power from the wind .Small wind generators, ranging from 400 watts to 40 kilowatts or more, can meet the needs of an entire farm or can be targeted to specific applications. In Texas and the West, for example, many ranchers use wind generators to pump water for cattle. Electric wind generators are much more efficient and reliable than the old water-pumping fan-bladed windmills. They may also be cheaper than extending power lines and are more convenient and cheaper than diesel generators.

"Net metering" enables farmers to get the most out of their wind turbines. When a turbine produces more power than the farm needs at that moment, the extra power flows back into the electricity system for others to use, turning the electric meter backwards. When the turbine produces less than the farm is using, the meter spins forward, as it normally does. At the end of the month or year, the farmer pays for the net consumption or the electric company pays for the net production. Net metering rules and laws are in place in most states.

4.3. Hydro Energy: Hydroelectric power comes from the natural flow of water. The energy is produced by the fall of water turning the blades of a turbine. The turbine is connected to a generator that converts the energy into electricity. The amount of electricity a system can produce depends on the quantity of water passing through a turbine (the volume of water flow) and the height from which the water 'falls' (head). The greater the flow and the head, the more electricity produced.

Hydropower is a clean, domestic, and renewable source of energy. It provides inexpensive electricity and produces no pollution. Unlike fossil fuels, hydropower does not destroy water during the production of electricity. Hydropower is the only renewable source of energy that can replace fossil fuels' electricity production while satisfying growing energy needs.

Hydroelectric systems vary in size and application. Micro-hydroelectric plants are the smallest types of hydroelectric systems. They can generate between 1 kW and 1 MW of power and are ideal for powering smaller services such as processing machines, small farms, and communities. Large hydroelectric systems can produce large amounts of electricity. These systems can be used to power large communities and cities.

4.4. Biomass Energy: Authorities studies reveal that that the forest cover of country is depleting every year at a rate more than 1.5 million hectares.

The situation is particular grave in rural areas. This rate of deforestation is alarming. Much of the wood felled is used as fuel for cooking. Charring and briquetting technologies reduce various problems associated with the management and utilization of biomass in domestic and industrial sectors. Briquetting of some of the crop residues has becomes cost competitive and the briquettes being used as replacement of firewood in many regions of the country.

Domestic biogas plants instal1ed in our country use cattle dung mixed with an equal quantity of water to maintain 8-9% total solids concentration (TSC) in the influent slurry. The effluent discharged from the plants is, in general, col1ected into the slurry pits or spread on to the ground for drying before transportation to fields for use as organic manure.

5. Conclusion

The only realistic solution to the problem go non-renewable is to find sources of renewable energy to replace today's dwindling supplies of affordable and usable fossil energy. Solar energy is the only source of truly renewable energy – renewable at least for the next few billion years. Windmills, falling water, solar collectors, and photovoltaic cells are all sources of renewable solar energy. The most common solar energy collectors are green plants. After all, plants were the original collectors of today's fossil energy. So, it's only logical to look to agriculture as a renewable source of alternative energy for the future. However, we need to be realistic about the extent to which energy from agriculture can replace our current use of fossil energy. While the energy experts may not agree on specific quantities or percentages, the overall limits on energy from agriculture are fairly basic and straightforward.

6. References:

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Course Name	Renewable Energy
Lesson No. 2	Familiarization with biomass utilization
Course Reviser	Kiran Nagajjanavr
University Name	University of Horticultural Science, Bagalkot
Course Reviewer	Atul Ganeshrao Mohod
University Name	Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli

Objectives: By the end of this lecture, students will be able to:

- Explain biomass utilization for biofuel production and their sources
- Application of biofuels in agriculture and allied sector
- Differentiate advantages and disadvantages of biofuels and fossil fuels
- Contribution of biofuels in agriculture

Introduction:

Biomass is the material derived from plants that use sunlight to grow which include plant and animal material such as wood from forests, material left over from agricultural and forestry processes, and organic industrial, human and animal wastes. Biomass energy is a type of renewable energy generated from biological (such as, anaerobic digestion) or thermal conversion (for example, combustion) of biomass resources.

Biomass comes from a variety of sources which include:

- Wood from natural forests and woodlands
- Forestry plantations
- Forestry residues
- Agricultural residues such as straw, stover, cane trash and green agricultural wastes
- Agro-industrial wastes, such as sugarcane bagasse and rice husk
- Animal wastes
- Industrial wastes, such as black liquor from paper manufacturing
- Sewage
- Municipal solid wastes (MSW)
- Food processing wastes

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Fig. 1. Sources of Biomass

Detailed and accurate characterization of biomass feedstock, intermediates, and products is a necessity for any **biomass-to-biofuels conversion**. Understanding how the individual biomass components and reaction products interact at each stage in the process is important for researchers.

With a large inventory of standard biomass samples as reference materials, NREL maintains a biomass feedstock composition and property database with the chemical, thermal, and mechanical properties of various biomass feedstock materials.

NREL's biomass characterization capabilities include:

Developing standard laboratory analytical procedures NREL wrote most of the standard biomass laboratory analytical procedures for characterization that are used throughout the research community. At NREL, we develop new methods and tools to understand more about chemical composition of raw biomass feedstock and the solid, liquid, and slurry samples produced during conversion.

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Performing real-time biomass analysisNREL combines multivariate analysis with near-infrared spectroscopy to provide real-time biomass analysis. Using this rapid analysis technique, researchers can analyze a wide range of physical and chemical characteristics of raw and processed biomass within minutes instead of days. Investigating structural changes Researchers investigate structural changes in biomass from the plant tissue to the macromolecular scale using established and advanced imaging tools in the Biomass Surface Characterization Laboratory. NREL has developed methods to visualize the deconstruction of plant cell walls during biomass conversion. This provides an understanding, for example, of the behavior of lignin during the pretreatment process or of the interactions between enzymes and the biomass cell wall. With such a wide range of biomass sources and production process variables, understanding the chemical composition of the material becomes an important issue.

Typical biomass components

(a) Cellulose : A polysaccharide in which D-glucose is linked uniformly by β-glucosidic bonds. Its molecular formula is $(C_6H_{12}O_6)_n$. The degree of polymerization, indicated by n, is broad, ranging from several thousand to several tens of thousands. Total hydrolysis of cellulose yields D-glucose (a monosaccharide), but partial hydrolysis yields a disaccharide (cellobiose) and polysaccharides in which n is in the order of 3 to 10. Cellulose has a crystalline structure and great resistance to acids and alkalis.

(b) Hemicellulose : A polysaccharide whose units are 5-carbon monosaccharides including D-xylose and D-arabinose, and 6-carbon monosaccharides including D-mannose, D-galactose, and D-glucose. The 5-carbon monosaccharides outnumber the 6-carbon monosaccharides, and the average molecular formula is $(C_5H_8O_4)_n$. Because the degree of polymerization n is 50 to 200, which is smaller than that of cellulose, it breaks down more easily than cellulose, and many hemicelluloses are soluble in alkaline solutions. A common hemicellulose is xylan, which consists of xylose with 1,4 bonds. Figure 2.3.1-c shows the structural formula of xylan. Other hemicelluloses include glucomannan, but all hemicelluloses vary in amounts depending on tree species and the part of the plant.

(c) Lignin: A compound whose constituent units, phenylpropane and its derivatives, are bonded 3-dimensionally. Its structure is complex and not yet fully understood. Figure 2.3.1-d shows a constituent unit. Its complex 3-dimensional structure is decomposed with difficulty by microorganisms and chemicals, and its function is therefore thought to be conferring mechanical strength and protection. Cellulose, hemicellulose, and lignin are universally found in many kinds of biomass, and are the most plentiful natural carbon resources on Earth.

(d) Starch : Like cellulose, starch is a polysaccharide whose constituent units are D-glucose, but they are linked by α-glycosidic bonds. Owing to the difference in the bond structures, cellulose is not water-soluble, while part of starch is soluble in hot water (amylose, with amolecular weight of about 10,000 to 50,000, accounting for 10%–20% of starch) and part is not soluble (amylopectin, with a molecular weight of about 50,000 to 100,000, accounting for 80%–90% of starch). Starch is found in seeds, tubers (roots), and stems, and has a very high value as food.

(e) Proteins : These are macromolecular compounds in which amino acids are polymerized to a high degree. Properties differ depending on the kinds and ratios of constituent amino acids, and the degree of polymerization. Proteins are not a primary component of biomass, and account for a lower proportion than do the previous three components.

(f) Other components (organic and inorganic) : The amounts of the other organic components vary widely depending on specie, but there are also organic components with high value, such as glycerides (representative examples include rapeseed oil, palm oil, and other vegetable oils) and sucrose in sugarcane and sugar beet. Other examples are alkaloids, pigments, terpenes, and waxes. Although these are found in small amounts, they have very high added value as pharmaceutical ingredients. Biomass comprises organic macromolecular compounds, but it also contains inorganic substances (ash) in trace amounts. The primary metal elements include Ca, K, P, Mg, Si, Al, Fe, and Na. Substances and their amounts differ according to the feedstock type.

The fuel produced from biological materials is known as Biofuel. Biofuels are a renewable energy alternative which can be made from crops grown on the farm to fuel vehicles. Biomasssuch as sugars and oils from plants can be used to make fuel for vehicles (popularly known asBiofuel or Biodiesel) and the burning of biomass for the production of heat or electricity is simply calledBiopower. Biodigestors, a simple closed system for biological decomposition of waste (Ojomoet al. 2018). Though it generates carbon dioxide when utilized, the biomass was created from solar energy, water and carbon dioxide, and so does not increase the earth's net volume of carbon dioxide. In this respect, biomass is said to be "carbon neutral"

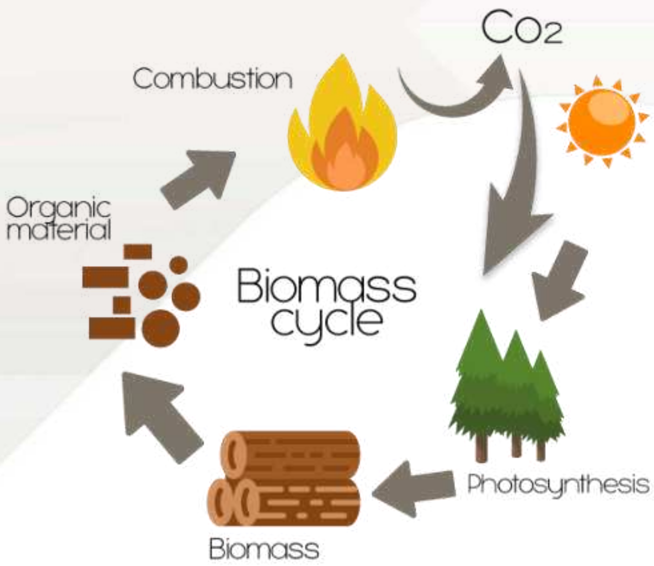

Fig. 2. Utilization of Biomass Energy

1. Biomass Classification

One of the most commonly used and documented classification of biomass is as woody or non-woody. The non-woody biomass included agricultural crops, crop residues, processing residues and animal wastes. Some perennial grasses (e.g. Miscanthus, elephant grass) are now grown as energy crops. The forest residue such as leaves, twigs and herbaceous matter are also a source of biomass. The Food and Agriculture Organization (FAO) classifies bioenergy into following three main groups: Wood fuels, Agro-fuels and urban waste based fuels.

1.1. Agricultural energy crops: Crops grown specifically for energy production include Jatropha, Miscanthus and other perennial grasses.

1.2. Agricultural residues: Includes crop and plant residues produced in the field such as cereal straw, leaves and plant stem. It is also a source of animal feed and soil nutrient and conditioner.

1.3. Processing residues: These include residues resulting from agro industrial conversion or processing of crops (Including tree crops), such as pomace, bagasse, nutshells, grain husks and saw dust.

1.4. Animal waste: These comprise waste from both intensive and extensive animal husbandry.

1.5. Agro-Industrial plantation: Biomass collected as a by-product from plantation crops like tea, coffee, rubber trees, oil and coconut palms, bamboo and other tall grasses.

1.6. Forest plantation and Natural forest: Plantation includes both commercial plantations (pulp and paper, furniture) and energy plantation (trees dedicated to producing energy such as charcoal and other energy uses). It also included the biomass available from natural forest.

1.7. Forest Residues: Includes dropping of trees in the form of leaves, branches and twigs.

1.8. Others: It includes trees grown outside forest or woodland, including bush trees, roadside trees and on-farm trees.

2. Biofuel

Biofuel is a type of fuel whose energy is derived from biological carbon fixation. Biofuels include fuels derived from biomass conversion (Figure 2), as well as solid biomass, liquid fuels and various biogases. Although fossil fuels have their origin in ancient carbon fixation, they are not considered biofuels by the generally accepted definition because they contain carbon that has been "out" of the carbon cycle for a very long time. Biofuels are gaining increased public and scientific attention, driven by factors such as oil price hikes, the need for increased energy security, concern over greenhouse gas emissions from fossil fuels, and support from government subsidies. Biofuel is considered carbon neutral, as the biomass absorbs roughly the same amount of carbon dioxide during growth, as when burnt. Biodiesel as one from important biofuel types is made from vegetable oils and animal fats. Biodiesel can be used as a fuel for vehicles in its pure form, but it is usually used as a diesel additive to reduce levels of particulates, carbon monoxide, and hydrocarbons from dieselpowered vehicles. Biodiesel is produced from oils or fats using trans-esterification.

Bioethanol is an alcohol made by fermentation, mostly from carbohydrates produced in sugar or starch crops such as corn or sugarcane. Cellulosic biomass, derived from non-food sources such as trees and grasses, is also being developed as a feedstock for ethanol production. Ethanol can be used as a fuel for vehicles in its pure form, but it is usually used as a gasoline additive to increase octane and improve vehicle emissions. Bioethanol is widely used in the USA and in Brazil. Current plant design does not provide for converting the lignin portion of plant raw materials to fuel components by fermentation.

3. Different sources of biofuel

There are 4 biofuel sources, with some of their application in developmental stages, some actually implemented:

3.1. Algae

Algae come from stagnant ponds in the natural world, and more recently in algae farms, which produce the plant for the specific purpose of creating biofuel. Advantage of algae focused on the followings: No CO_2 back into the air, self-generating biomass, Algae can produce up to 300 times more oil per acre than conventional crops. Among other uses, algae have been used experimentally as a new form of green jet fuel designed for commercial travel. At the moment, the upfront costs of producing biofuel from algae on a mass scale are in process, but are not yet commercially viable.

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3.2. Carbohydrate (sugars) rich biomaterial

It comes from the fermentation of starches derived from agricultural products like corn, sugar cane, wheat, beets and other existing food crops, or from inedible cellulose from the same. Fuel produced from existing crops, can be used in an existing gasoline engine, making it a logical transition from petroleum. It used in Auto industry, heating buildings ("flueless fireplaces"). At present, the transportation costs required to transport grains from harvesting to processing, and then out to vendors results in a very small net gain in the sustainability stakes.

3.3. Oil rich biomaterial

It comes from existing food crops like rapeseed, sunflower, corn and others, after it has been used for other purposes, i.e. food preparation ("waste vegetable oil", or WVO), or even in first use form ("straight vegetable oil", or SVO). Not susceptible to microbial degradation, high availability, re-used material. It is used in the creation of biodiesel fuel for automobiles, home heating, and experimentally as a pure fuel itself. At present, WVO or SVO is not recognized as a mainstream fuel for automobiles. Also, WVO and SVO are susceptible to low temperatures, making them unusable in colder climates.

3.4. Agriculture wastes (organic and inorganic sources)

It comes from agricultural waste which is concentrated into charcoal-like biomass by heating it. Very little processing required, low-tech, naturally holds CO_2 rather than releasing it into the air. Primarily, biochar has been used as a means to enrich soil by keeping CO_2 in it, and not into the air. As fuel, the off-gasses have been used in home heating. There is controversy surrounding the amount of acreage it would take to make fuel production based on biochar viable on a meaningful scale. Furthermore, use of agriculture wastes which is rich in inorganic elements (NPK----) as compost (fertilizer) in agriculture.

4. Biogas

The biogas technology is based on the phenomenon of microbial decomposition of organic matter in the absence of air to yield a gas, mainly consisting of methane and carbon-dioxide. In this process different groups of microbes act upon complex organic matter in four stages. In the first stage, the hydrolytic bacterias degrade the high molecular weight substances like celluluose, starch, protiens, fats etc. present in the organic matter into small molecular weight compounds like fatty acids, amino acids, carbon-dioxide and hydrogen. In the second stage, the acetogenic bacterias act upon the end products of the first stage and convert them into acetates and hydrogen. Simultaneously, a third group of bacterias called homoacetogens convert the hydrogen and simply carbon components produced in first and second stage into acetates. In the fourths stage, the methanogens covert the actates and some other simple compounds like formate, carbon-dioxide and hydrogen into methane. This methane can be collected and used as a source of energy.the established organic product after digestion contains substances and can be used as a source of humus and plant nutrients.

Common factors affecting biogas production are type of basic organic material, temperature, pH of media, solid concentration, agitation etc. the materials having high lignin content are difficult to decompose and are not preferred for bio gasification. However, materials having non-lignin C: N 20 to 25:1 are good for bio gasification. Therefore, with a C: N ratio of 20:1 animal dung is considered to be suitable material for bio gas production.

The biogas production with naturally occurring microbes takes place within the temperature of 10-40℃. However, a temperature of 33 to 35 ℃ maximum amount of biogas can be produced per unit weight of dry organic materials under atmospheric conditions.

The acid forming microbes can function well within the pH range of 5.5 to 7.5, whereas the methane generating microbes function well within the pH range of 6.5 to 8.5, therefore, the pH range of 6.5 to 7.5 is optimum.

The optimum solid content for biogas production is 8 to 12 %. The 1: 1 input of water and dung with 18 to 20 % solid makes the solid contents to 9-10 % and the same is recommended for biogas production. Slow agitation/ mixing of slurry helps in improving the biogas production.

Constituents of biogas

- Methane (50-65%)

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- Carbon dioxide (30-40%)
- Hydrogen (1-5%)
- Nitrogen (1%)
- Hydrogen sulphide (0.1%)
- Oxygen (0.1%)
- Water vapours (0.1%)

5. Bio-ethanol

It is an environmentally friendly fuel for vehicles that normally run on petrol. As a renewable source of energy, it reduces demand on fossil fuels while it burns more cleanly and with reduced emissions of CO_2, a greenhouse gas. As an energy source, bio-ethanol is carbon neutral in that it reduces, by up to 70 %, the amount of greenhouse gas released into the atmosphere. The CO_2 released during ethanol production and combustion in an engine has already been absorbed from the atmosphere during the growth of the crops due to photosynthesis.

Bio-ethanol is produced by the fermentation of sugar, a well-established process used in the production of beer and alcohol.

Carbohydrates such as starch from cereal and tuber crops – which is enzymatically converted into simple sugars – and natural sugars from sugar beet, sugar cane and sweet sorghum crops are fermented using yeast to produce a mash containing ethanol, water and unfermented solids. Distillation columns separate ethanol from the fermented mash, with additional purification taking place in rectification columns to produce an ethanol and water mixture. Dehydration is the step of removing the last of the water, taking the mixture beyond its azeotropic equilibrium to produce anhydrous ethanol, or bio-ethanol.

A significant advantage of bio ethanol is that it can be blended with petrol as both an oxygenator and octane enhancer. Environmental concerns due to the widespread use of MTBE (methyl tertiary butyl ether, a possible carcinogen) in unleaded petrol have prompted drives to seek alternatives. Bio-ethanol provides an ideal solution in that it is a renewable and environmentally friendly petrol extender, while providing a direct substitute for MTBE as an octane enhancer. Ethanol is also suitable as a feedstock for producing other octane enhancers such as ETBE (ethyl tertiary butyl ether) or TAEE (tertiary amyl ethyl ether), considered safer than MTBE.

6. Bio diesel

For the esterification of Jatropha oil, alkaline-based catalyst is used in this plant. The Jatropha oil is blended with alcohol and catalyst mixture. The oil extracted from the seeds of Jatropha is mixed with methanol catalyst mixture at a proportion under a particular temperature. This solution is continuously stirred for two hours. During the above process, glycerol present in the solution separate out, which when settled can be separated out. For settling, three separate tanks are provided in the plant. After removing the glycerol, the liquid biodiesel is transferred to washing tank, where the fuel is washed twice and the purified biodiesel is obtained.

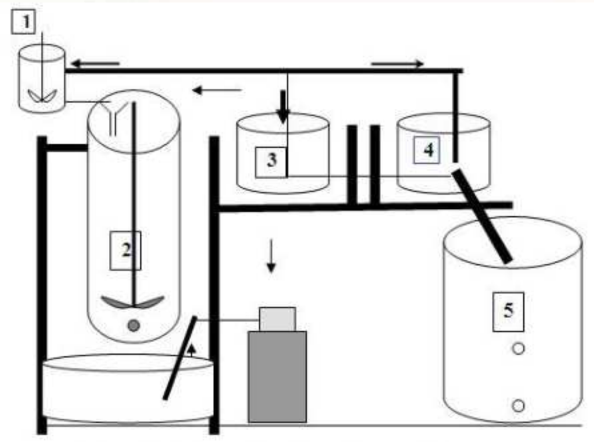

Fig. Biodiesel pilot plant diagrammatic sketch

1. Mixing tank for chemical

2. Main reactor

3 & 4. Settling tanks

5. Washing tank

References:

Ojomo, A. O., Falayi, F. R. and Ogunlowo, A. S. (2018).Development of a DensificationEquipment for Organic Biomass Solid Fuel Pellets. Journal of Engineering and Technology, **3**(1): 108-112

Course Name	Renewable Energy
Lesson No. 3	Types of Biogas plants and Gasifiers
Course Reviser	Kiran Nagajjanavr
University Name	University of Horticultural Science, Bagalkot
Course Reviewer	Atul Ganeshrao Mohod
University Name	Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli

Objectives: By the end of this lecture, students will be able to:

- Explain type of biogas plants with neat diagram
- Compare among different models of biogas plant
- Explain type of gasifiers with neat diagram

1. Introduction

The production of biogas from anaerobic digestion is widely used by modern society for the treatment of livestock manure and slurries. The aim is to produce renewable energy and to improve their fertilizer quality. In countries with significant agricultural production, the strengthening of environmental legislation and regulation of manure and vegetable wastes recycling increased the interest for anaerobic digestion as a cheap and environmental friendly solution. Anaerobic digestion is today standard technology for stabilization of primary and secondary sewage sludge, for treatment of organic industrial waste from foodprocessing and fermentation industries as well as for the treatment of the organic fraction of municipal solid waste.

Most organic materials undergo a natural anaerobic digestion in the presence of moisture and absence of oxygen and produce biogas. The biogas so obtained is a mixture of methane (CH_4): 55-65% and Carbon dioxide (CO_2): 30-40%. The biogas contains traces of H_2, H_2S and N_2. The calorific value of biogas ranges from 5000 to 5500 Kcal/Kg (18.8 to 26.4 MJ /m^3). The biogas can be upgraded to synthetic natural gas (SNG) by removing CO_2 and H_2S. The production of biogas is of particular significance in India because of its large scale cattle production. The biogas is used for cooking, domestic lighting and heating, run I.C. Engines and generation of electricity for use in agriculture and rural industry. Family biogas plants usually of 2-3 m^3 capacity.

2. Advantages

- The initial investment is low for the construction of biogas plant.
- The technology is very suitable for rural areas.

- Biogas is locally generated and can be easily distributed for domestic use.
- Biogas reduces the rural poor from dependence on traditional fuel sources, which lead to deforestation.
- The use of biogas in village helps in improving the sanitary condition and checks environmental pollution.
- The by-products like nitrogen rich manure can be used with advantage.
- Biogas reduces the drudgery of women and lowers incidence of eye and lung diseases.

Raw materials for biogas generation Biogas is produced mainly from

- Cow dung
- Sewage
- Crop residues
- Vegetable wastes
- Water hyacinth
- Poultry droppings
- Pig manure

Digestion is biological process that occurs in the absence of oxygen and in the presence of anaerobic organisms at temperatures (35-70ºc) and atmospheric pressure. The container in which, this process takes place is known as digester.

3. Anaerobic digestion:

The treatment of any slurry or sludge containing a large amount of organic matter utilizing bacteria and other organisms under anaerobic condition is commonly referred as anaerobic digestion. Anaerobic digestion consists of the following three stages, namely: (i) the enzymatic hydrolysis, (ii) acid formation and (iii) methane formation.

3.1. Enzymatic hydrolysis: In this stage, a group of facultative microorganisms acts upon the organic matter and convert insoluble, complex, high molecular compounds of biomass into simple, soluble, low

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molecular compounds. The organic substances such as polysaccharide, protein and lipid are converted into mono-saccharide, peptide, amino acids, and fatty acids. Then they are further converted into acetate, propionate and butyrate.

3.2. Acid formation: The microorganisms of facultative and anaerobic group collectively called as acid formers, hydrolyze and ferment the productions of first phase i.e., water soluble substances into volatile acid. The major component of the volatile acid is the acetic acid. In addition to acetate or hydrogen and carbon dioxide, some other acids like butyric acid and propionic acid are also produced.

3.3. Methane formation: Finally, acetate or hydrogen plus carbon dioxide are converted into gas mixture of methane (CH_4) and CO_2 by the bacteria, which are strictly anaerobes. These bacteria are called methane fermenters. For efficient digestion, these acid formers and methane fermenters must remainin a state of dynamic equilibrium.The remaining indigestible matter is referred as “slurry”

The following are some approximate rules used for sizing biogas plants or for estimating their performance:

1. One kg of dry cattle dung produces approximately 1 m^3 of biogas.
2. One kg of fresh cattle dung contains 8% dry biodegradable mass.
3. One kg of fresh cattle dung has a volume of about 0.9 liters.
4. One kg of fresh cattle dung requires an equal volume of water for preparing slurry.
5. Typical retention time of slurry in a biogas plant is 40 days.

4. The efficiency of biogas generation depends upon the following factors:

1. Acid formers and methane fomenters must remain in a state of dynamic equilibrium, which can be achieved by proper design of digester.

2. Anaerobic fermentation of raw cow dung can takes place at any temperature between 8 and 55°C. The value of 35°C is taken as optimum. The rate of biogas formation is very slow at 8°C. For anaerobic digestion, temperature variation should not be more than 2 to 3°C. Methane bacteria work best in the temperature range of 35 and 38°C.
3. A pH value between 6.8 and 7.8 must be maintained for best fermentation and normal gas production. The pH above 8.5 should not be used as it is difficult for the bacteria to survive above this pH.
4. A specific ratio of carbon to nitrogen (C/N ration) must be maintained between 25:1 and 30:1 depending upon the raw material used. The ratio of 30:1 is taken as optimum.
5. The water content should be around 90% of the weight of the total contents. Anaerobic fermentation of cow dung proceeds well if the slurry contains 8 to 9% solid organic matter.
6. The slurry should be agitated to improve the gas yield.
7. Loading rate should be optimum. If digester is loaded with too much raw material, acids will accumulate and fermentation will be affected.

5. Types of biogas plants: Biogas plants basically are two types.

1. Floating dome type: e.g. KVIC-type (KVIC- Khadi Village Industries Commission)
2. Fixed dome type: e.g.Deenabandu model
3. Fixed dome With Expansion Chamber type

5.1. Floating dome/ KVIC type biogas plant

This mainly consists of a digester or pit for fermentation and a floating drum for the collection of gas. Digester is 3.5-6.5 m in depth and 1.2 to 1.6 m in diameter. There is a partition wall in the center, which divides the digester vertically and submerges in the slurry when it is full. The digester is connected to the inlet and outlet by two pipes. Through the inlet, the dung is mixed with water (4:5) and loaded into the digester. The fermented material will flow out through outlet pipe. The outlet is generally connected to a compost pit. The gas generation takes place slowly and in two stages. In the first stage, the complex, organic substances contained in the waste are acted upon by a certain kind of bacteria, called acid formers and broken up into small-chain simple acids. In the second stage, these acids are acted upon by another kind of bacteria, called methane formers and produce methane and carbon dioxide.

The gas holder is a drum constructed of mild steel sheets. This is cylindrical in shape with concave. The top is supported radically with angular iron. The holder fits into the digester like a stopper. It sinks into the slurry due to its own weight and rests upon the ring constructed for this purpose. When gas is generated the holder rises and floats freely on the surface of slurry. A central guide pipe is provided to prevent the holder from tilting. The holder also acts as a seal for the gas. The gas pressure varies between 7 and 9 cm of water column. Under shallow water table conditions, the adopted diameter of digester is more and depth is reduced. The cost of drum is about 40% of total cost of plant. It requires periodical maintenance. The unit cost of KVIC model with a capacity of 2 m^3/day costs approximately Rs.14, 000/-

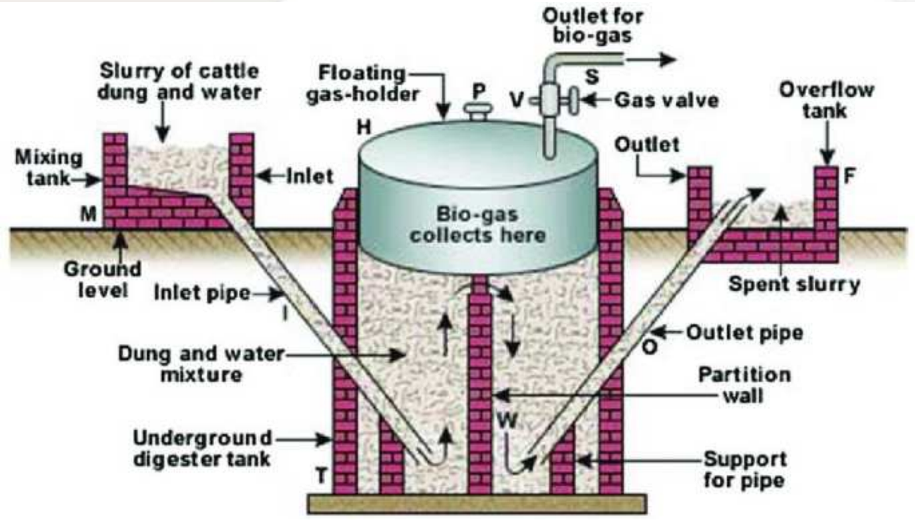

Fig. 1. Schematic diagram of a KVIC biogas plant

5.2. Fixed dome/ Janata type biogas plant

The design of this plant is of Chinese origin but it has been introduced under the name "Janata biogas plant" by Gobar Gas Research Station, in view of its reduced cost. This is a plant where no steel is used, there is no moving part in it and maintenance cost is low. The plant can be constructed by village mason taking some pre-explained precautions and using all the indigenously available building materials. Good quality of bricks and cement should be used to avoid the afterward structural problems like cracking of the dome and leakage of gas. This model have a higher capacity when compared with KVIC model, hence it can be used as a community biogas plant. This design has longer life than KVIC models. Substrates other than cattle dung such as municipal waste and plant residues can also be used in Janata type plants. The plant consists of an underground well sort of digester made of bricks and cement having a dome shaped roof which remains below the ground level is shown in figure (2). At almost middle of the digester, there are two rectangular openings facing each other and coming up to a little above the ground level, act as an inlet and outlet of the plant. Dome shaped roof is fitted with a pipe at its top which is the gas outlet of the plant. The principle of gas production is same as that of KVIC model. The biogas is collected in the restricted space of the fixed dome, hence the pressure of gas is much higher, which is around 90 cm of water column.

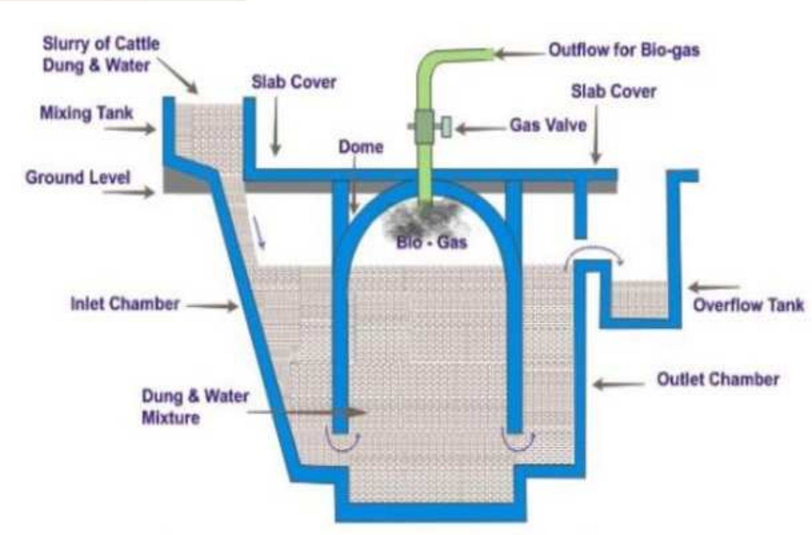

Fig. 2. Fixed dome type bio-gas plant

5.3. Fixed dome With Expansion Chamber type/Deenbandhu biogas plant:

Deenbandhu model was developed in 1984, by Action for Food Production (AFPRO), a voluntary organization based in New Delhi. Schematic diagram of a Deenabandhu biogas plantentire biogas programme of India as it reduced the cost of the plant half of that of KVIC model and brought biogas technology within the reach of even the poorer sections of the population. The cost reduction has been achieved by minimizing the surface area through joining the segments of two spheres of different diameters at their bases. The cost of a Deenbandhu plant having a capacity of 2m^3/day is about Rs.8000/-. The Deenbandhu biogas plant has a hemispherical fixed-dome type of gas holder, unlike the floating dome of the KVIC-design is shown. The dome is made from pre-fabricated ferrocement or reinforced concrete and attached to the digester, which has a curved bottom. The slurry is fed from a mixing tank through an inlet pipe connected to the digester. After fermentation, the biogas collects in the space under the dome. It is taken out for use through a pipe connected to the top of the dome, while the sludge, which is a by-product, comes out through an opening in the side of the digester. About 90 percent of the biogas plants in India are of the Deenbandhu type.

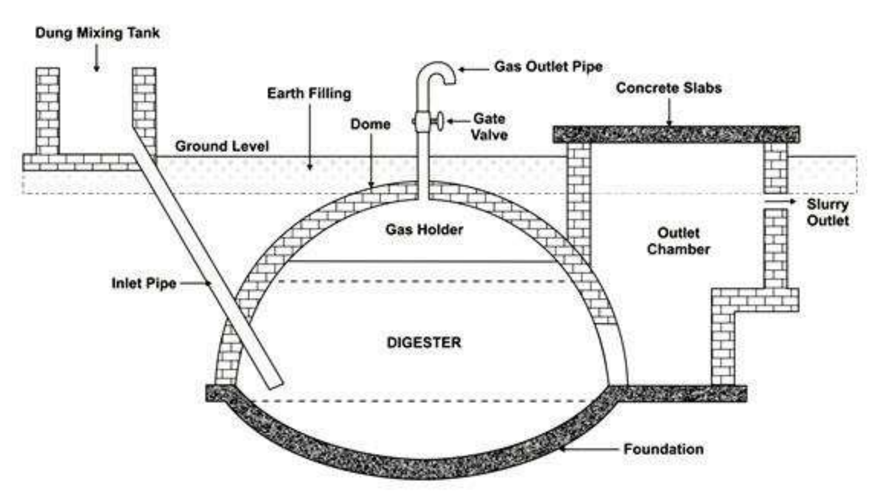

Fig. 3. Schematic diagram of a Deenabandhumodel biogas plant

6. Biomass as a source of energy

The world over, biomass fuels represent the second largest source of energy used after fossil fuels. In developing countries about two thousand million people rely almost entirely on biomass fuels for their energy needs. It represents about 35 percent of the energy used. About 40 percent of the total energy consumed in India, even today, comes from fuel wood, charcoal and various agricultural residues. About half of all the trees cut in the world, for whatever reasons; end up being used as fuel for cooking and heating. The present methods for utilization of these resources are highly inefficient. On the other hand, utilization of the residues through gasification route becomes economical and promising for thermal and power to rural areas and for small scale agro industries. This will also reduce the pressure on the worsening fuel wood situation. Agro residues are available abundantly and can also be used for gasification.

7. Gasification

Biomass gasification is a process of converting solid biomass fuel into a gaseous combustible gas (called producer gas) through a sequence of thermo-chemical reactions under controlled atmosphere. It involves burning of tightly packed organic matter with a limited air supply at temperature above 1100 °C. This gives producer gas which has a energy content of about 1/6th of that petroleum gas. The gas produced in the gasifiers is a clean burning fuel having calorific value between 1000- 1200 kcal/m^3 (kilo calorie per cubic metre). Hydrogen (18-20 %) and carbon monoxide (18-24 %) are the main constituents of the gas.

In gasifiers,a solid fuel is converted by a series of thermo-chemical processes like:

- Drying (upto 120 °C)
- Pyrolysis (200-600 °C)
- Oxidation (900-1200 °C)
- Reduction (900-600 °C)

In complete combustion, carbon dioxide is obtained from the carbon and water from the hydrogen. Oxygen from the fuel will of course be incorporated in the combustion products, thereby decreasing the amount of combustion air needed.

Oxidation, or combustion, is described by the following chemical reaction formulae:

$C + O_2 \leftrightarrow CO_2$ -401.9 kJ/mol

$H + \frac{1}{2}O_2 \leftrightarrow H_2O$ -241.1 kJ/mol

These formulae mean that burning 1 gram atom, i.e. 12.00 g of carbon, to dioxide, a heat quantity of 401.9 kJ is released, and that a heat quantity of 241.1 kJ results from the oxidation of 1 gram molecule, i.e. 2.016 g of hydrogen to water vapour.

In all types of gasifiers, the carbon dioxide (CO_2) and water vapour (H_2O) are converted (reduced) as much as possible to carbon monoxide, hydrogen and methane, which are the main combustible components of producer gas.

The following are main gasification stages are described.

Drying: It is very 1st thermal reaction on the fuel wood feed in the unit. Biomass is fed at the top of gasifier hopper and it moves down as the process proceeds. As it moves down it experiences the drying process. Usually, air dried biomass contains moisture in the range of 13-15 %. The heat radiation from the oxidation zone, evaporates the moisture of biomass in the upper most layer. The temperature of this zone remains <120℃.

Pyrolysis: As the dried mass moves down, it is subjected to stronger heating from the oxidation zone. At temperature above 200℃, the material starts losing its volatiles. No air is admitted until then. Once temperature reaches 400℃, a self-sustaining exothermic reaction takes place in which the material structure of wood or other organic solids breaks down. Water vapour, methane, acetic acid and considerable quantity of heavy hydrocarbon tars are evolved. This zone in which biomass loses all its volatile and gas converted into two parts.

1. Primary Pyrolysis zone : Temperature ranges from 200-600℃
2. Secondary pyrolysis zone : Temperature ranges from 300-800℃

Oxidation: The actual combustion of char pyro lysed gases and tars takes pace in this zone. A calculated quantity of air is supplied through air nozzles provided for the purpose. This raises temperature to 900-1200℃. The Principle reaction is

$C + O_2 \rightarrow CO_2$ + Heat

$CH_4 + O_2 \rightarrow CO_2 + H_2O$+ + Heat

The tar is cracked in the high temperature. The products of oxidation zone are higher temperature gases containing products and water vapour.

Reduction: The products of oxidation zone passes through reduction zone. It is the packed bed of charcoal. This charcoal is initially supplied from external sources. The zone is maintained within close temperature limits of 900-800℃

$CO_2 + C \rightarrow 2CO$

$C + H_2O \rightarrow CO + H_2$

$C + 2H_2O \rightarrow CO_2 + 2H_2$

$C + 2H_2 \rightarrow CH_4$

CO production is the principal reaction in the reduction zone. The products are combustible, most of H_2 produced in the reduction zone remains free. Only some of it combines with carbon to form methane.

8. Types of gasifiers:

There are three types of gasifiers, namely:

- Updraft gasifiers
- Downdraft gasifiers
- Cross draft gasifiers

8.1. Updraft gasifiers:

The air intake is at the bottom and the gas leaves at the top. Near the grate at the bottom the combustion reactions occur, which are followed by reduction reactions somewhat higher up in the gasifier. In the upper part of the gasifier, heating and pyrolysis of the feedstock occur as a result of heat transfer by forced convection and radiation from the lower zones. The tars and volatiles produced during this process will be carried in the gas stream. Ashes are removed from the bottom of the gasifier.

The major advantages of this type of gasifier are its simplicity, high charcoal burn-out and internal heat exchange leading to low gas exit temperatures and high equipment efficiency, as well as the possibility of operation with many types of feedstock (sawdust, cereal hulls, etc.).

Major drawbacks result from the possibility of "channeling" in the equipment, which can lead to oxygen break-through and dangerous, explosive situations and the necessity to install automatic moving grates, as well as from the problems associated with disposal of the tar-containing condensates that result from the gas cleaning operations. The latter is of minor importance if the gas is used for direct heat applications, in which case the tars are simply burnt.

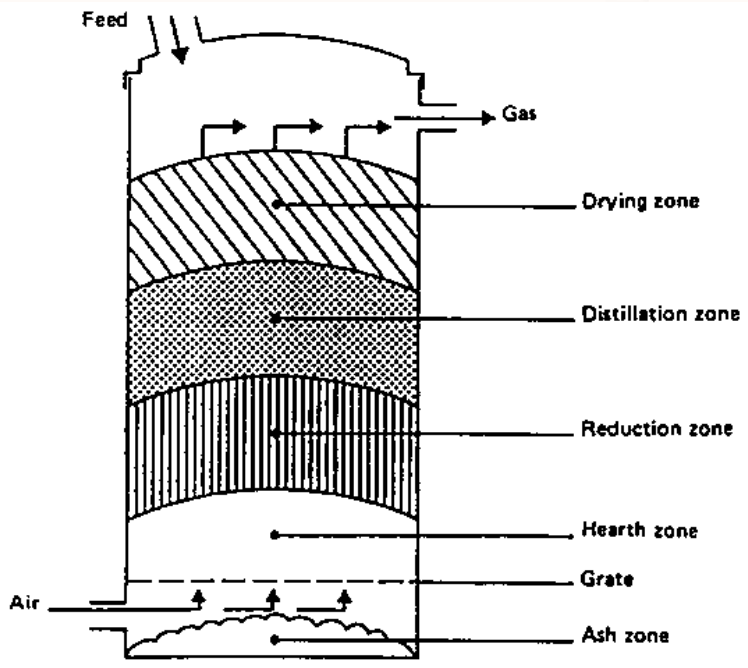

Fig. 4. Updraft or counter current gasifier

8.2. Downdraft/ co-current gasifier

A solution to the problem of tar entrainment in the gas stream has been found by designing co-current or downdraught gasifiers, in which primary gasification air is introduced at or above the oxidation zone in the gasifier. The producer gas is removed at the bottom of the apparatus, so that fuel and gas move in the same direction, as schematically shown in Fig. 5.

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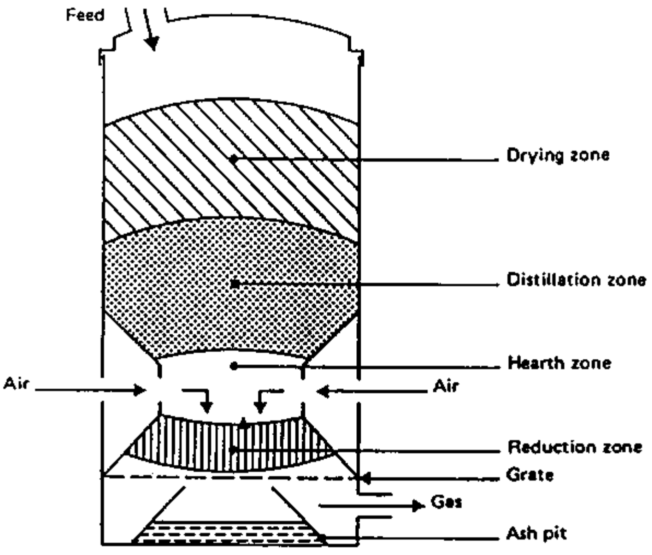

Fig. 5. Downdraft or co-current gasifier

On their way down the acid and tarry distillation products from the fuel must pass through a glowing bed of charcoal and therefore are converted into permanent gases hydrogen, carbon dioxide, carbon monoxide and methane.Depending on the temperature of the hot zone and the residence time of the tarry vapours, a more or less complete breakdown of the tars is achieved.

The main advantage of downdraught gasifiers lies in the possibility of producing a tar-free gas suitable for engine applications.Because of the lower level of organic components in the condensate, downdraught gasifiers suffer less from environmental objections than updraft gasifiers.

A major drawback of downdraught equipment lies in its inability to operate on a number of unprocessed fuels. In particular, fluffy, low density materials give rise to flow problems and excessive pressure drop, and the solid fuel must be pelletized or briquetted before use. Downdraught gasifiers also suffer from the problems associated with high ash content fuels (slagging) to a larger extent than updraft gasifiers.

8.3.Cross-draft gasifier

Cross-draft gasifiers, schematically illustrated in Figure 6 are an adaptation for the use of charcoal. Charcoal gasification results in very high temperatures (1500 °C and higher) in the oxidation zone which can lead to material problems. In cross draught gasifiers insulation against these high temperatures is provided by the fuel (charcoal) itself.

Advantages of the system lie in the very small scale at which it can be operated. Installations below 10 kW (shaft power) can under certain conditions be economically feasible. The reason is the very simple gas-cleaning train (only a cyclone and a hot filter) which can be employed when using this type of gasifier in conjunction with small engines.

A disadvantage of cross-draught gasifiers is their minimal tar-converting capabilities and the consequent need for high quality (low volatile content) charcoal.

It is because of the uncertainty of charcoal quality that a number of charcoal gasifiers employ the downdraught principle, in order to maintain at least a minimal tar-cracking capability.

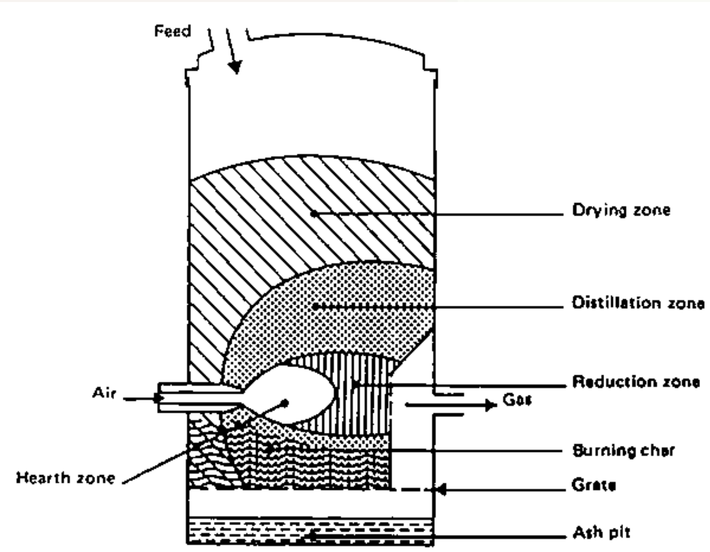

Fig.6. Cross-draft gasifier

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http://www.fao.org/3/t0512e/T0512e0a.htm#TopOfPage

http://ecoursesonline.iasri.res.in/mod/page/view.php?id=1258

Acknowledgement:

Course Name	Renewable Energy
Lesson No. 4	Introduction of Solar energy
Course Reviser	Kiran Nagajjanavr
University Name	University of Horticultural Science, Bagalkot
Course Reviewer	Atul Ganeshrao Mohod
University Name	Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli

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Objectives: By the end of this lecture, students will be able to:

- Discover best ways to replace electrical gadgets with solar gadgets apart from gadgets explained in this lecture.
- Contribution of solar energy in agriculture.

1. Introduction

Widespread use of solar energy for domestic, agricultural and agro-industrial activities has been practiced almost since the development of civilization. Increasing threat of acute shortage of the commercial sources of energy coupled with serious environmental pollution problems has accelerated interest in the scientific exploitation of renewable sources of energy. Energy available from the sun is inexhaustible and environment friendly. Therefore, the solar energy technologies are likely to play an important role in the near future through a variety of thermal applications and decentralized power generation and distribution systems.
The power from the sun intercepted by the earth is approximately 1.8 x lO^{ll} MW. This makes it one of the most promising unconventional energy sources. Solar energy is available in abundance in most part of our country throughout the year. In India,' the annual average daily solar radiation received over the whole of the country is around 1800 J/cm^2/day. Drying of various agricultural produce in open sunlight is an age-old practice. Development of various solar devices for thermal applications such as water heating and space heating, drying, cooking and power generation began during the last century

2. Solar Energy Technologies

There are two ways to convert solar energy into electrical energy; a system using photovoltaic technology and another that uses solar capture heating systems. In the photovoltaic system, the sun rays are converted directly to electricity by semiconductors. In addition, in the method of heating, electrical power *via* the thermodynamic processes, with help of heat exchange equipment, can be converted to mechanical energy. These two methods are centralized and non-centralized. The photovoltaic method leads to more investments. However, in recent years with advances in the field of solar energy, thermal methods are used for power supply.

3. Solar Photovoltaic Systems

Solar photovoltaic (SPV) cells were invented at Bell Labs in the United States in 1954, and they have been used in space satellites for electricity generation since the late 1950s. In this technology, SPV cell converts electromagnetic energy of incident radiation directly into electrical power. Although a junction of two dissimilar material exhibits the photovoltaic phenomenon, its effect is more profound when semiconductors are employed. The most common type of semiconductor currently in use is made of silicon crystal. Silicon crystal laminated into n-type and p-type layers, stacked on top of each other. Light striking the crystals induces the 'photovoltaic effect', which generates electricity. The electricity produced is direct current (DC) and can be used immediately or stored in a battery. For system installed on homes served by a utility grid, a device called an inverter changes the electricity into alternate current (AC), the standard power used in residential homes.

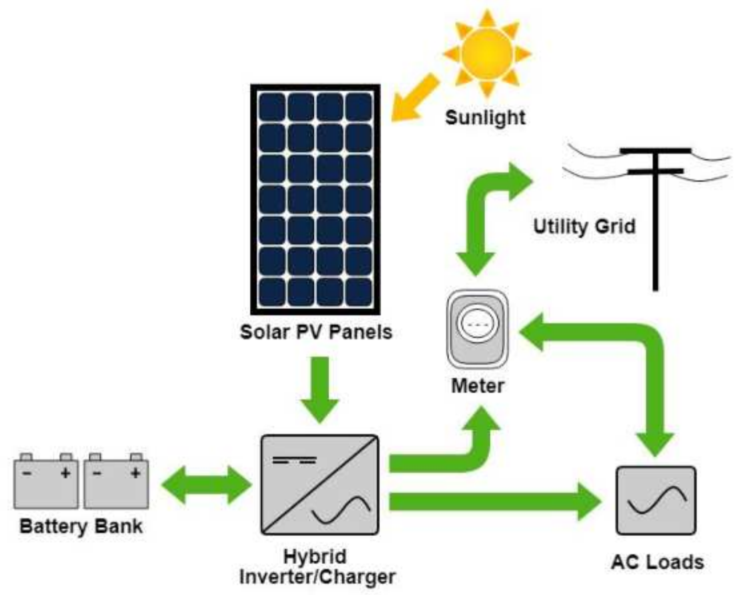

Fig. 1. Solar photovoltaic system

(Source: http://www.apricus.com/solar-pv-systems-29/#.X_LHy9gzbIU)

3.1. Solar Photovoltaic Application

The solar photovoltaic (SPV) panel may be used for lighting, water pumping, communication etc. This is one of the best options for remote rural areas where either the power supply from state grid is not available or is unreliable.

3.1.1. Solar Home lighting system: It consists of SPV module, electronic control and charging system, battery and compact fluorescent lamps (CFL) these lamps are being replaced by more efficient light emitting diodes which are more efficient and have longer life's.

3.1.2. SPV-based street lighting system: It consists of SPV module, electronic control, battery, luminary pole, etc.

3.1.3. SPV water-pumping system: It is suitable for lifting water for drinking and irrigation purposes. These pumps can be installed in tanks, cisterns or rivers and tube wells. The SPV pumping system of 900 W_p and 1800 W_p are more commonly available for irrigation purpose.

3.1.4. SPV-based refrigerator: The SPV power can be used for operating a refrigerator. To operate commercial refrigerator, the power generated by SPV panel requires conversion from direct current (DC) to alternative current (AC) through an inverter. Low efficiency and high starting current result into high capacity and expensive SPV power supply system. Hence, presently available solar refrigerators are DEC compressor based; it mainly consists of solar photovoltaic array, charge controller, battery bank, DC compressor, condenser and evaporator, refrigerator cabinet box, thermostat, *etc*. the refrigerator is provided with battery backup for 2-3 cloudy days to maintain low temperature of the products. Usually the refrigerator maintains 3-6 °C temperature inside.

4. Solar Thermal System

Solar energy collectors are special kind of heat exchangers that transform solar energy radiant to internal energy of the transport medium. There are two types of collectors: flat-plate and concentrating collector.

4.1. Flat-plate collector (FPC): The flat-plate solar collector is used for heating a liquid. Solar radiation passes through the transparent cover on the blackend absorber plate and a major portion of this energy is absorbed by the plate and then transferred to the transport medium in the fluid tubes to be carried away as usable energy. The transport medium can be liquid or gaseous, usually water or air. The transparent cover of the collector is used to reduce convection heat losses from the absorber plate. Flat plate collectors are generally used for temperature (60-70℃) applications it is commonly used for water heating, air heating etc and doesn't require tracking. Radiation losses from the absorber of a solar energy collector can be reduced when the receiving surfaces have selective radiation properties. Selective surfaces have very high absorptivity for radiation in the solar range of wavelength and low emissivity for long wave thermal radiation. Effective selective surfaces have solar absorptivity near 0.95 and thermal emissivity near 0.1.

4.2. Concentration collector: Concentrating solar collectors are designed to collect heat by solar parabolic, solar trough and solar towers. Concentrating collector is a device to collect solar energy with high intensity of solar radiation on the energy absorbing surface. Such collectors use optical system in the form of reflectors or refractors. These collectors are used for medium (100-300 ℃) and high-temperature (above 300 ℃) applications such as steam production for the generation of electricity. The high temperature is achieved at absorber because of reflecting arrangement provided for concentrating the radiation at required location using mirrors and lenses.

These collectors are best suited to places having more number of clear days in a year. The area of the absorber is kept less than the aperture through which the radiation passes, to concentrate the solar flux. These collectors require tracking to follow the sun because of optical system. The tracking rate depends on the degree of concentration ratio and needs frequent adjustment for system having high concentration ratio. The efficiency of these collectors lies between 50-70 %. The collectors need more maintenance than FPC because of its optical system. The concentrating collectors are classified on the basis of reflector used; concentration ratio and tracking method adopted.

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5. Application in Agriculture and allied activities

Solar energy can be used for low and medium temperature thermal application such as heating, drying, water heating, industrial process heating, *etc*

5.1. Solar dryers

Open sun drying of various agricultural produce is the most common application of solar energy. With the objective of increasing the drying rate and improving quality of the produce, natural convection and forced convection type solar dryers have been developed for various commodities. The movement of air in the forced convection solar dryer is through a power blower whereas in natural convection solar dryer air moves through the produce due to natural thermal gradient.

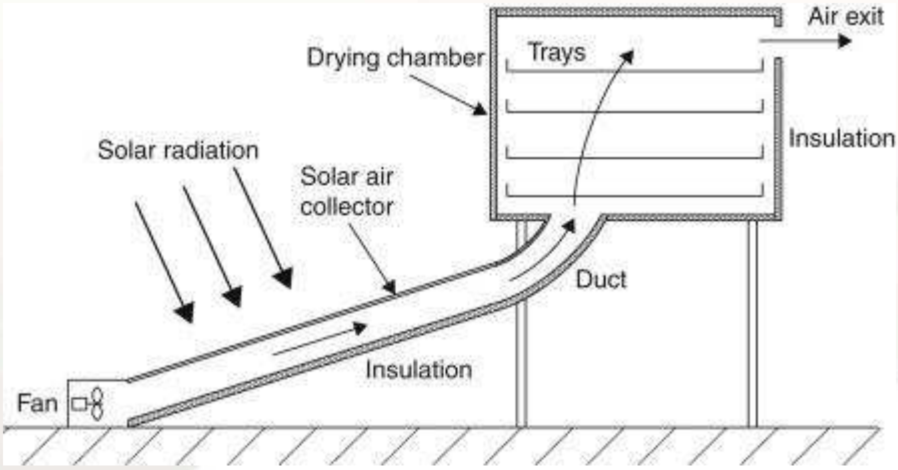

Fig. 2. Schematic diagram of solar dryer (Gupta *et al*., 1982)

5.2. Solar cookers

Solar cookers are systems of clean energy, available and inexpensive sun that is used for cooking food. The box type solar cooker is the most common. It consists of a cooking box, mirror reflector and cooking vessels. The double glass cover (spaced at 10-12 mm) at top act as transparent insulator. A trapezoidal shaped trough is provided to keep cooking boxes in the solar cooker. The exposed face of the trough is provided to keep cooking boxes in the solar cooker. The exposed face of the trough is painted matt black to act as absorber. The side and bottom portions of the box are insulated to reduce heat loss. Cooking pots made of aluminum and painted matt black are used. A reflector mirror is provided with box to increase solar isolation and raise the stagnant temperature inside the box. The stagnant temperature in the box varies between 100 and 150 ℃ (with single reflector). The standard size of the cooker box is 600 mm × 600 mm × 200 mm. it is suitable for cooking for 4-5 members of a family. The solar cooker is kept open in sun, facing south and cooking time (for rice and pulses) is 2-2$\frac{1}{2}$h depending on intensity of sun and ambient temperature.

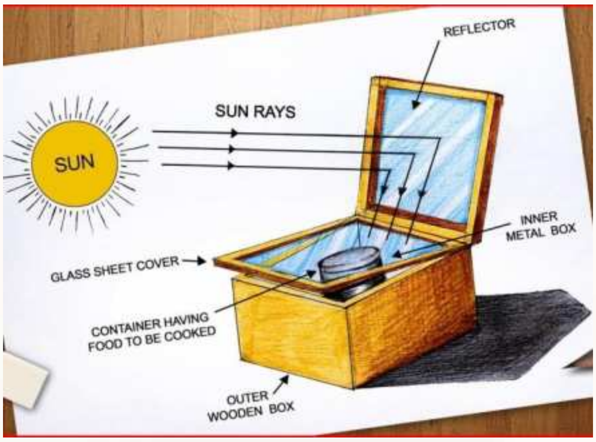

Fig. 3. Solar cooker

3. Solar water heaters

Water heating is one of the most common applications of solar energy for domestic and industrial applications. They are also available in natural convection and forced convection designs. Natural convection water heating systems also known as thermo syphon water heating system consist of a flat plate solar collector, insulated water storage tank and necessary insulated pipe fittings. No pumping is required as the hot water naturally rises into the closed coupled storage tank. It is usually designed up to capacity of500 l/day. For higher capacities, a pump is used to circulate the hot water between collectors and storage tank. A 100 l/d capacity solar heater can save electrical energy to the tune of 1200-1500 kWh/year.

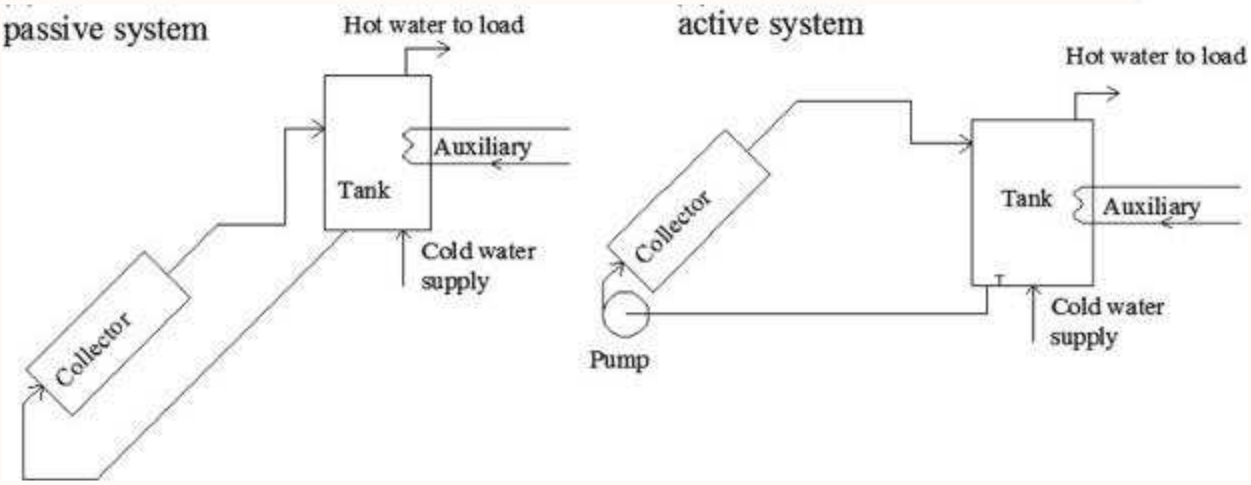

Fig. 4. Natural and forced circulation water heating system (Letcher and Fthenakis, 2018)

4. Solar pond:

Solar pond is simply a pool of salt-water that collects and stores solar thermal energy. The salt water naturally forms a vertical salinity gradient also known as a 'halocline', in which low salinity water floats on top of high salinity water. The layers of salt solutions increase in concentration (and therefore density) with depth. Below a certain depth, the solution has a uniform high salt concentration. When solar energy is observed by water its temperature increases, causing thermal expansion and reduced density. The temperature gradient alone causes a density gradient that increases with depth, and this counteracts the temperature gradient, thus preventing heat in the lower layers from moving upwards by convection and leaving the pond. This means that the temperature at the bottom of the pond raises to over 90°C while the temperature at the top of the pond is usually around 30°C. Heat trapped in the salty bottom layer can be used for many different purposes, such as heating of buildings, Drying, industrial hot water, desalination, refrigenaration or to drive an organic Rankine cycle turbine or stirling Engine for generating electricity.

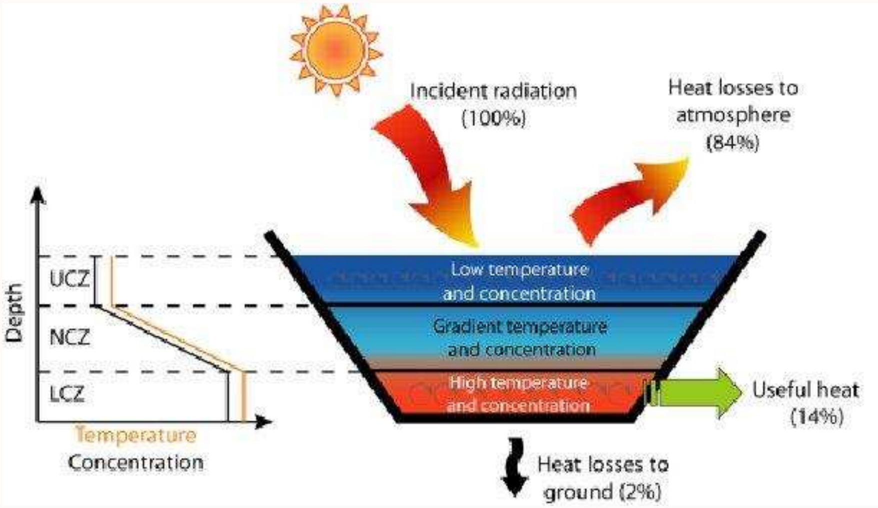

Fig. 5. Schematic of salt-gradient solar pond (Suarez *et al*., 2010)

5. Solar distillation:

Solar distillation is a device to desalinate impure water like brackish or saline or polluted water. It consists of shallow basin, the bottom of which is painted black to absorb solar heat effectively. Top of the basin is covered with tilted transparent glass. Saline water is charged in the basin. Water gets heated and evaporates slowly by absorbing solar heat. The evaporated water vapour gets condensed on the sloping glass cover by using latent heat and become water drops, which flow into a storage container. The distillation capacity of such stills range between 2.5-3l/m^2/d.

The process of solar distillation is analogous to the naturally occurring hydrologic cycle.

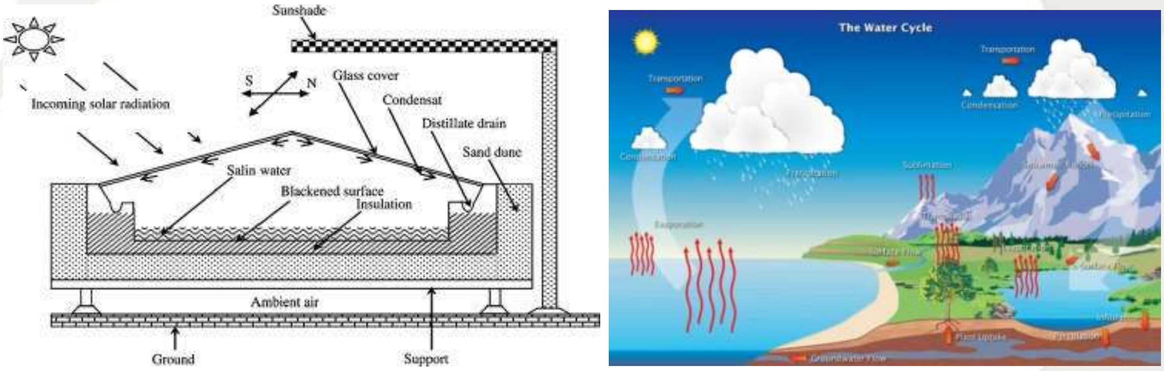

Fig. 6. Solar distillation tank

Course Name	Renewable Energy
Lesson No. 5	Wind energy
Course Reviser	Kiran Nagajjanavr
University Name	University of Horticultural Science, Bagalkot
Course Reviewer	Atul Ganeshrao Mohod
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Objectives: By the end of this lecture, students will be able to:

- Application of wind energy in agriculture and allied sector
- Major drawback of wind energy

1. Introduction

The wind systems that exist over the earth's surface are a result of variations in air pressure.These are in turn due to the variations in solar heating. Warm air rises and cooler air rushesin to take its place. Wind is merely the movement of air from one place to another. There areglobal wind patterns related to large scale solar heating of different regions of the earth'ssurface and seasonal variations in solar incidence. They are also localized wind patternsdue the effects of temperature differences between land and seas, or mountains and valleys.Wind speed generally increases with height above ground. This is because the roughness ofground features such as vegetation and houses cause the wind to be slowed.Wind speed data can be obtained from wind maps or from the meteorology office.Unfortunately the general availability and reliability of wind speed data is extremely poor inmany regions of the world. However, significant areas of the world have mean annualwindspeeds of above 4-5 m/s (metres per second) which makes small-scale wind poweredelectricity generation an attractive option. Small wind systems can providepower that can be used directly or stored in batteries. Thesesystems are very reliable in areas that get enough consistentwind. The systems can be very cost-effective and reliable formany power needs on farms and ranches.

2. Application of Wind Energy

2.1. Water pumping using wind turbine

Wind turbine electricity generation can be used to raisethe living standard of rural dwellers by improving agriculturalproductivity. Wind turbine has significant benefit in the areaswhere there is a shorter rainy season and hence demand forpumped water. After installing wind turbine water pumps in afarm, one can raise higher value crops throughout the year andalso supply water to the livestock. There is the requirement ofappropriate training for the local farmers to use wind turbinebasedwater pump irrigation. At present, mostly fossil fuelpoweredwater pumps are used in the farms. Other applications ofwind power using water pumps are: domestic water supply,water supply for livestock, drainage, salt ponds, fish farms, etc.

2.2.Electricity generation from wind turbine

The demand for electricity is growing with the increase inpopulation, especially in rural areas which are not connectedto the electrical grid. Therefore, provision of electricity to theremote rural communities can be made cheaply at the startfrom a wind power system as compared with other options,e.g. extension of grid power lines or other types of fossil fuelwhich are hard to transport due to poor road networks to therural communities. Wind energy needs to be promoted first tothe farms which are in great need of electricity to contributesignificant improvement in the crop yield from agriculture.Small, highly efficient wind turbines can be installed in ruralfarms. The cost of installing one wind turbine is close tothat of putting up electrical poles, overhead power lines andother equipment necessary to connect to the electrical grid.The advantage is that the farm owner owns the generatingequipment and is freed frompaying monthly electrical bills.

2.3.Grinding grains and legumes using windmills

Wind energy can be used for grinding grains and legumes.Long before the invention of electricity, early wind turbinesdid very useful work for grinding. Windmills were used inmany places in Europe over the last several centuries to turnheavy granite disks called millstones. The millstones wereused to crush dry grains such as wheat, barley and corn tomake flour or meal. This technique can be applied on farmsfor production of flour.

3. How wind energy can help farmers

Farmers and ranchers are in a unique position to benefit from the growth in the wind industry. To tap this market, farmers can lease land to wind developers, use the wind to generate power for their farms, or become

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wind power producers themselves. Farmers and ranchers can generate their own power from the wind .Small wind generators, ranging from 400 watts to 40 kilowatts or more, can meet the needs of an entire farm or can be targeted to specific applications. In Texas and the West, for example, many ranchers use wind generators to pump water for cattle. Electric wind generators are much more efficient and reliable than the old water-pumping fan-bladed windmills. They may also be cheaper than extending power lines and are more convenient and cheaper than diesel generators.

"Net metering" enables farmers to get the most out of their wind turbines. When a turbine produces more power than the farm needs at that moment, the extra power flows back into the electricity system for others to use, turning the electric meter backwards. When the turbine produces less than the farm is using, the meter spins forward, as it normally does. At the end of the month or year, the farmer pays for the net consumption or the electric company pays for the net production. Net metering rules and laws are in place in most states.

4.Environmental impact of wind energy farming

Wind energy farming is an environmentally-friendlyoption,with the following features:

- It is pollution-free: reduces air and noise pollution;
- It does not require fuel for operation;
- It does not produce toxic or radioactive waste;
- It does not create greenhouse gases (each mega-watt hour generated by wind energy helps to reduce 0.8 to 0.9 tonnes/year of greenhouse gas emissions that are producedby coal or fossil fuel generation each year);
- Reduces concentrations of CO2, SO2, NO*X*, thereby reducing acid rain;
- Concerns about noise pollution and “visual pollution” of the landscape;

- When large arrays of wind turbines are installed on farmland, only about 2% of the land area is required for the wind turbines. The rest is available for farming, livestock, and other uses;
- Birds could be killed when they run into the turbine.

5. Economic feasibility of wind energy farms

- Landowners, farmers and ranchers often receive payments for the use of their land, which enhances their income and increases the value of the land.
- Operational and maintenance cost is low.
- Zero input fuel cost.
- It is domestic, reducing the need for import of fossil fuels. This helps in reducing gas emission from transportationof fuels.

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