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# UNIT 18 GREEN TECHNOLOGIES FOR NATURAL RESOURCE CONSERVATION

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## Structure

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- Green energy offers a promising substitute for conventional energy sources;
- Green technology (GT) is an arena of finding innovative ways to make eco-friendly changes in the daily life.
- Green technology (GT) helps in conservation of natural resources and environment.

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## 18.0 INTRODUCTION

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Economic development is directly linked with the energy consumption. The growing energy demand to meet the developmental goals has not only increased the use of fossil fuels but has increased the carbon emissions resulting in global environmental problems. The scientific community is constantly making world aware that the growing demand for energy cannot be met with from current energy sources. It is becoming difficult to achieve sustainable development unless the renewable sources are explored and harnessed in a judicious manner. Thus, energy use efficiency must be increased to regulate energy growth and at the same time the input from clean energy sources has to be improved to diminish the harmful environmental impacts of development. Green energy offers a promising substitute to the conventional energy sources. Research has shown that the renewable energy can turn out to be a promising solution for many problems, but the need of the hour is to assess the potential of renewable sources and constraints in using them on commercial scale. These hurdles, either financial or non-financial have to be identified and tackled to design

innovative policy or renewable energy technologies to meet the global and domestic energy demands. Renewable energy can facilitate in meeting the basic energy requirements through the use of modern green technologies. The Rio Declaration adopted at United Nations Conference on Environment and Development stresses on right to healthy and productive human life in harmony with environmental conservation in the development process. On 14th June, 1992, The Earth Summit at Rio adopted Agenda 21 which suggests measures to be executed to speed-up the sustainable development.

Before discussing the green technologies, it is important to understand different forms of green energy. Hydropower is presently the major producer of green energy, accounting for over 70 per cent of renewable energy. Solar energy is another form of green energy, which can be used at domestic and commercial level. Wind energy is source of renewable power, which is more cost-effective than solar and hydropower. Geothermal energy on other the hand works by tapping the intrinsic heat hidden in earth. Biomass is mainly the change of wood chips and fragments, unused sugar, animal manure into electricity. Biomass can also include materials produced precisely for energy production. The biomass is burned and the heat energy is converted into electricity.

Green Technology is an umbrella term that defines the use of science & technology to produce products and facilities that are eco-friendly. It is related to clean technology, which indeed refers to the products and facilities that improve operational performance thus decreasing prices, energy consumption, waste generation, or negative consequences on the environment. Green Technology (GT) is a comprehensive term and is an arena of finding innovative ways to make eco-friendly changes in the daily life. It is produced and used in a way that helps in the conservation of natural resources and environment. It is an alternate source of technology that decreases the dependence on fossil fuels, validates and exhibits less damage to human, animal, and plant health and ecosystem on the whole. It is basically based on the principles which seek to achieve energy independence and promote effective resource use; conserve and lessen the impact on environment; enhance the economic development through the use of technology and improve the quality of life. Thus, Green Technology refers to the products, equipment or systems which:

- lessens the degradation of environment;
- has zero or low greenhouse gas (GHG) emission;
- is safe to use and promotes healthy environment for all living beings;
- conserves energy and natural resources while augmenting the economic development and improving the national economy;
- encourages the utilization of renewable resources; and
- ensures sustainable development by protecting the environment for future generations

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## **18.1 OBJECTIVES**

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After studying this unit, you will be able to understand:

- evolution of green technologies;

- role of green technologies in conservation of natural resources;
- prospects of agroforestry and organic farming; and
- concept of green buildings.

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## 18.2 GREEN TECHNOLOGIES: HISTORICAL AND CONTEMPORARY PERSPECTIVES

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Kautilya's Arthashastra deliberates about science and art of settlement planning, architecture and governance of natural resources in detail. Dholavira in Gujarat of Indus Valley civilization had constructed lakes to harvest monsoon runoff for drainage and drinking water. Rainwater retaining devices of early Harappan period were discovered in Baluchistan and Sindh Kohistan.

Before the scientific world coined the term Green Technology, the man, since times immemorial, has been using the sun, water and wind as a source of energy for achieving various tasks. Man used power sources to assist their daily life, for instance, horses for transportation, donkeys for labour, and so on. India has an age-old repository of traditional knowledge that has not only helped in the survival of human civilization in the past but can help in reducing the energy consumption, thereby paving the way for the development of green technologies. The Green Technology, though a recent phrase, has long historical background. Ancient Indian civilizations have always respected environment, which is reflected in the use of local and sustainable materials, water harvesting and climate-responsive architectural designs. Architectural elements like courtyards, wind towers, roof terraces and stone lattices, among others, are used for effective temperature control. Sustainability has been a vital element of Indian culture. Its thinking and principles have emphasized a sustainable way of life. Man, and nature share a harmonious relationship which has helped in conservation of environment and biodiversity. Yog and Ayurved are perhaps among the most well-known traditions of inclusive Indian living. Sustainable and ecofriendly practices still continue to be the part of lifestyle and culture. Rural people, which constitute about 70 per cent of Indian population, live a simple and frugal life close to nature. Ancient Indians knew the science and art of settlement planning, architecture and governance of natural resources. Kautilya's Arthashastra discusses about these aspects in detail. Archaeologists have found evidence of early Indian hydraulic engineering. Dholavira of Indus Valley civilization presently located in Gujarat had constructed lakes to harvest monsoon runoff, drainage and drinking water. Rainwater retaining devices of early Harappan period were discovered in Baluchistan and Sindh Kohistan. British Gazettes wrote about these systems. Desert city of Jaisalmer in Rajasthan is a best instance of conventional Indian rainwater harvesting. Likewise, the traditional farming existed in India until 1700 or so. At large, this was a sustainable agriculture, enough to meet the local requirements, and used a range of 'organic techniques', for instance, recycling organic material, use of locally-adapted crop strains; crop rotation and intercropping, including legumes; and biological pest control. Livestock rearing was combined with farming.

However, discovery of modern steam engine in the mid-1700s, brought about industrial revolution. In 1800s, more and more natural resources, such as, coal, oil and petroleum were found to be useful energy sources. However, with the passage of time, due to huge consumption of fossil fuels there started occurring energy crisis across the world and this prompted man to again look back and turn towards the renewable energy sources. But the challenge was to reunite the ancient methods with contemporary technological innovations.

Today, green technology represents different forms of clean energy, renewable and sustainable energy, waste management and energy conservation. But it is difficult to trace the history of green technology. However, there are certain links which correlate the ancient green technology ideas with modern inventions. 19th century witnessed a torrent of alternate energy activity, mainly in France. In 1839, Edmond Becquerel invented the photovoltaic effect which paved the way for the first silicon solar cell in 1954. In 1859, Gaston Plante invented the lead acid battery and demonstrated it at the French Academy of Sciences. In 1860, August Mouchet proposed the idea of solar-powered steam engines. In 1900s, there were energy crisis in the Middle East and things got worse in year 1973 when the restriction levied by oil producers of Iraq on America increased the price of crude oil.

United States were awakened by oil crisis and understood the significance of energy resources, which initiated a push for evolving the clean energy. In 1978, the National Energy Act became a landmark first step in starting the research & development of renewable energy, but the endeavours for renewable standards actually started in the 1960s. In the 1970s, Japan, Denmark and other countries decided to invest in solar, biomass, wind and other technologies to wean themselves from fossil fuels. But, the current wave of green technology can be traced back to 2001 after various declarations and conclaves on environment protection and climate change were organized. In the year 2003, various nations introduced financial incentives for companies for energy efficacy and promotion of renewable energy that generate electricity from renewable energy sources and adoption of energy-saving activities. The industrial-setups were exempted from import duty and sales tax for machines, equipment, materials and spare parts to be used in the generation of electricity from renewable energy sources. However, these initiatives resulted in promoting green technologies and at present, green technology has found applications in following fields:

- Agriculture
- Aircraft and travel
- Automobile industry
- Computer and Information Technology
- Construction
- Consumer products
- Education
- Food processing
- Health
- Industrial mechanization
- Portable drinking water
- Sustainable energy

#### **Advantages of Opting Green Technology**

- Brings about economic development

- Doesn't release anything detrimental into the environment, protects environment, green marketing value, etc.
- Provides opportunity to have own energy generation system
- It is renewable and inexhaustible

### **Disadvantages of Adopting Green Technology**

- Alternate process/ technology, chemical/ raw material inputs are lesser-known
- Ambiguity about the performance impacts
- High cost of implementation
- Lack of information
- Non-availability of human resources and skills

### **Applications of Green Technology**

#### **1. Building Sector**

- Construction, managing, maintenance and dismantling of buildings

#### **2. Energy Sector**

- Energy supply management in industrial and commercial sectors
- Power generation

#### **3. Transportation**

- Transportation infrastructure and vehicles (biofuels and public transport)

#### **4. Water and Waste Management**

- Management and utilization of water resources, wastewater treatment and solid waste landfill

### **Future Prospects of Green Technology**

While talking about the future of green technology, the role of nanotechnology is worth mentioning. Nanotechnology is the handling of matter on an atomic, molecular, and supramolecular scale. The developing nanotechnology is likely to solve the basic needs of human beings. Nanotechnology refers to specific technological goal of specifically manipulating atoms and molecules for building of macroscale products. Planned development in nanotechnology leads to environmental sustainability and it can be used as green technology. Nanotechnology is primarily considered as green technology because it is clean, safe and inexpensive source of renewable energy. It helps in producing stronger, lighter, more sturdy recyclable materials; low-cost filters to provide clean drinking water; medical devices and drugs to detect and treat diseases more effectively with fewer or no side effects; systems to remove harmful chemicals in the environment; creation of green building and sustainable infrastructure and improved production methods to reduce the greenhouse gas emission. Green Technology can play a key role in improving agriculture

and food production systems. It can help in achieving sustainable agriculture by making interventions in Integrated Pest Management, soil conservation, wetland conservation, maintenance of crop diversity, nutrient management, agro-forestry, and marketing of green products. The revolution in agriculture is expected to solve the problems in agriculture sector. It is expected that progress in nanotechnology can provide solutions in farming using nano-sensors, nano-pesticides, and low-cost water purification. It is likely to contribute in plant gene therapy; producing pest resistant varieties, high yield crops that require less water and support sustainable environment.

Nanotechnology has the ability to offer efficient, cost-effective and ecofriendly sustainable solutions for providing portable water for human use and clean water for agricultural and industrial uses. Nanotechnology innovations in low-cost water purification can solve drinking water problem by providing sustainable drinking water.

Nanotechnology as a green technology can offer a solution through low-priced water purification, detection of contaminants at molecular level and improved filtration systems. Nanotechnology novelties in renewable energy can solve energy requirement of human beings for meeting their basic needs. Nanotechnology as green technology maintains large-scale renewable solar energy and wind energy production and distribution at low-cost without any ecological degradation, thus ensuring sustainable energy solution.

Nanotechnology can provide innovative prospects in construction sector by offering green solutions through energy effective, ultra-high strength, extra-durable and lightweight construction materials. Together with IT and software revolution, nanotechnology is likely to usher a new paradigm shift in construction technology. Nanotechnology can address key issues of green buildings related to energy, environment, and health. Nano-modification of cement is an emerging area. It is now possible to control the basic structure of cement to regulate the concrete properties, performance, and durability. Green Technology can play a significant role in aircraft & space travel. Potential applications where nanotechnology can impact space exploration are propulsion fuels, structural materials, smart uniforms, electronics, and life-supporting environment. Green nanotechnology is likely to provide materials which can be more effective, stronger, self-healing and lighter than what is presently accessible.

Green higher education is about creating knowledge, skills, attitudes and values linked with the environment and higher education plays a key role in creating and developing human capital. From the construction industry to management sector there is a need to produce sustainable future which means that green-oriented personals are required. The infrastructure has to be in such a way that building, energy costs, dependability and performance has a constructive impact on the environment. Constant research on green concepts, and promotion of green operation management is required in future.

The major area of green nanotechnology research is human health. Green nanotechnology research can offer incredible prospects in the field of medical sciences. Some of the nanotechnology applications can be inexpensive which can help in rapid diagnosis, innovation in drug delivery, and faster

development of novel drugs. Development is anticipated in pharmaceuticals and green nanotechnology, which will allow patients to drink fluids containing nanorobots programmed to attack and recreate the molecular structure of cancer cells and viruses. There's even assumption that nanorobots could slow or reverse the aging process, and life expectancy could increase considerably. The green nanotechnology will be able to increase the life span by facilitating the eradication of life-threatening diseases such as cancer, or by mending the damage to the body at cellular level. Green technology is likely to contribute food processing sector, including the use of various raw materials, processes, and end products and require special attention for upholding quality, safety, and nutritional properties through green technology. The technologies, for instance, bio-preservation, electromagnetic wave heating, non-thermal technologies, etc. under the canopy of biotechnology and nanotechnology have prospects to decrease the process-induced toxins in food and will have positive impact on food production and processing.

### Check Your Progress 1

- Note:** a) Write your answer in about 50 words.  
b) Check your progress with possible answers given at the end of the unit.

1. Define the term Green Technology.

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## 18.3 EFFECTIVE GREEN TECHNOLOGIES

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Green Technology indicates a system that uses groundbreaking approaches to make ecofriendly products. Going green or using ecofriendly technologies is among the various ways that countries across the world are looking for to stimulate the economic growth and improve the lives of its people. Green Technology makes use of renewable natural resources that never exhausts besides focusing on innovative energy generation methods. Global warming has now become an unescapable reality. It is an increasing problem which is not only upsetting the government and society but threatening the health and environment. One of the ways to fight against global warming is making use of green technologies. Some of the promising green technologies for commercial setup, which have evolved in the recent years are:

- **Emission-free Vehicles:** Also known as ecological vehicles, for the reason that their use does not have any detrimental impacts on the environment, emission-free vehicles help in reducing the pollution causing gases in the atmosphere.
- **Green-Gas Boilers:** In the recent years, the scientists have developed green boilers, which either consume less fuel or make use of renewable energy. Natural gas, although a fossil fuel, has a peculiarity that it doesn't

emits any toxic gases. It releases more water vapor and less carbon dioxide. In terms of emissions, it is most ecofriendly fuel. Thus, the natural gas boilers utilize the heat of the water vapor coming out of the chimney, and achieve higher thermal yields with less air pollution.

- **Perpendicular gardens and farms:** The setting-up of perpendicular gardens in the buildings save energy and is beneficial to the environment. These gardens don't require routine watering that involve excessive use of water, and since these are installed along a wall, these decrease the intense noise pollution. It reduces heating, saves energy and promotes air conditioning.
- **Reducing Industrial Emissions:** Various technologies have been developed in the recent years which not only help in reducing the emissions but in the management of air pollutants which can considerably reduce the greenhouse effect.
- **Self-Sufficient Constructions:** Self-sufficient constructions function themselves by means of generating energy without any external input. These include the use of photovoltaic panels and solar tracking systems.
- **Solar Energy:** Solar energy finds application in vacuum tube for hot water, photovoltaic collector to produce electricity and solar streetlamps. This has reduced the dependence on energy from hydrocarbons and fossil fuels and encourage green solutions.
- **Waste Management:** The increase in domestic and industrial waste has been inconsistent. Managing solid waste has now become an obligation of firms and individuals. Outstanding green technologies for instance, smart containers, automated food waste tracking systems and automated optical scanning technologies can help in categorizing of mixed plastics and separating them from others.
- **Waste-to-Energy:** This technology produces energy from garbage, which is in form of steam, hot water or electricity and can be used for different domestic and industrial processes.
- **Wastewater Treatment:** A lot has been done in the field of wastewater treatment, the important being the membrane filtration, microbial fuel cells, biological treatments and natural treatment systems. The aim behind is to make water potable or considerably decrease the releasing of pollutants into river or sea.
- **Waves Energy:** This initiative converts energy of waves into electrical energy.

Green Technology can play a key role in improving agriculture and food production systems. Green Technology can help in achieving sustainable agriculture by making interventions in Integrated Pest Management, soil conservation, wetland conservation, maintenance of crop diversity, nutrient management, agro-forestry, and marketing of green products.

Likewise, few alternative green technological interventions which can turn out to be beneficial at household level are:

- Installation of solar panels, solar water heaters, wind generators and rainwater harvesting systems
- Insulation of homes, use of double-pane windows, household energy monitors, and smart power strips



## 18.3.1 WIND TURBINES

Man has been using wind or its motion energy for various purposes, for instance, sailing, flying a kite, and generating electricity. Accessibility of solar and wind energy varies with geographic location, topography, microclimate and many other factors. Hence, understanding the availability of resources is important for designing the conversion devices, which could efficiently harness the potential of wind energy. The terms wind energy and wind power describe the process by which the wind is used to produce mechanical energy that can be used for specific tasks, such as grinding grain or pumping water or converting into electricity. Wind energy is a blend of three synchronized actions, viz. uneven heating of atmosphere by sun, irregularities of earth's surface and rotation of earth. Wind flow pattern and speed vary and are affected by water bodies, vegetation, and difference in terrain. A wind turbine, or a wind energy converter is a device that converts kinetic energy of wind into electrical energy. Wind turbines work on a simple principle, rather than using electricity to get wind, the wind turbines make use of wind to produce electricity. Wind turns the blades of a turbine around a rotor, which rotates a generator, thereby producing electricity. A wind turbine converts wind energy into electricity using the aerodynamic force, that work like a rotor blade of a helicopter. When wind moves across the blade, the air pressure on one side of blade decreases and the difference in the air pressure across two sides of blade causes both lift and drag. The force of lift is effective than the drag which set-off the rotor to spin. The rotor links the generator, either directly or through a shaft and a series of gears that speed-up the rotation. This conversion of aerodynamic force to spinning of a generator produces electricity.

Effective Green Technologies  
Emission-free Vehicles  
Green-Gas Boilers  
Perpendicular gardens and farms  
Reducing Industrial Emissions  
Solar Energy  
Waste Management  
Waste-to-Energy  
Wastewater Treatment  
Waves Energy

**Types of Wind Turbines:** There are two basic types of wind turbines:

- **Horizontal-Axis Turbines:** These have three blades and operate "upwind," with the turbine turning at the top of the tower so that the blades face the wind.
- **Vertical-Axis Turbines:** These turbines are omnidirectional, and don't need to be adjusted to point into the wind to operate.

**Design and Construction:** The horizontal axis turbines has three components, viz. the rotor, which includes the blades for transforming wind energy to low-speed rotational energy; the generator, which includes the electrical generator, the control electronics, and a gearbox, an adjustable-speed drive, or continuous variable transmission part for transforming low-speed incoming rotation to high-speed rotation appropriate for producing electricity and the surrounding structure, which includes the tower and rotor yaw mechanism.

**Advantages of Wind Turbines:** Wind power is lucrative source of energy. Wind is a natural source of energy and its supply is infinitely available. Wind energy is sustainable, because wind is basically a type of solar energy. Winds are produced by the warming of the atmosphere by the sun, rotation and surface irregularities of earth. It is a clean source of fuel and doesn't pollute air like power plants that depend on burning of fossil fuels, such as coal or natural gas, which emit particulate matter, nitrogen oxides, and sulfur dioxide—resulting in health problems and ecological damage. Wind turbines don't produce

atmospheric emissions that can cause acid rain, smog, or greenhouse gases.

**Limitations of Wind Turbines:** Even though the wind energy has many benefits, still it competes with conventional energy sources on a cost basis. The wind turbines can only be established at specific locations and in case the electricity produced has to be transmitted from the site of production to the site of use, the cost of setting-up the transmissions lines is higher. Though wind power plants have comparatively lesser impact on the environment as compared to traditional power plants, the concern occurs over the noise produced by the turbine blades and visual impacts on the landscape. The wind plants can have impact on local wildlife, for instance, birds are killed by flying into the spinning turbine blades.

### Check Your Progress 2

- Note:** a) Write your answer in about 50 words.  
b) Check your progress with possible answers given at the end of the unit.

#### 2. Enlist seven effective green technologies.

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### 18.3.2 SOLAR PANELS

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Renewable energy is gaining wider acceptance and countries across the world are taking steps for shifting to low-carbon economy with essential public and private participation. Solar energy can be transformed to electricity by making use of Photo Voltaic (PV) panels or concentrators. It has been seen that incoming solar radiation above 4.5kWh/m<sup>2</sup>/day supports concentrator-based electricity generation. Applications like solar water heaters and cookers meet the domestic needs of cooking and water heating, thereby helping in national level energy planning. Solar energy, which is radiant light and heat from the sun can be used with the help of technologies such as solar heating, photovoltaic, solar thermal energy, etc. It is the main source of renewable energy and its technologies are usually designated as either passive solar or active solar depending on the way they capture and release solar energy or convert it into solar power. The solar energy that hits the earth every second is equivalent to 4 trillion 100-watt light bulbs. Moreover, the solar energy that hits one square mile in a year is equal to 4 million barrels of oil. Thus, the potential of solar energy is huge. The International Energy Agency (IEA) stresses on the development of inexpensive, unlimited, and clean solar energy technologies with longer-lasting and worldwide benefits. The IEA believed that the dependence on solar energy would increase countries' energy security. The use of solar energy enhances sustainability, decreases pollution, lowers the costs of alleviating climate change, and lessens the fossil fuel prices. India is densely populated with high solar insolation, an ideal arrangement for using solar power. Moreover, the country's other energy resources are comparatively limited. There are numerous factors, which must

be taken into account before investing into a solar power plant. With about 300 clear, sunny days in a year, India's theoretic solar power reception on its land area is about 5,000 trillion kilowatt-hours (kWh) per year. Depending on the location, the daily average solar energy incident in India varies from 4 to 7 kWh/m<sup>2</sup> with about 1,500–2,000 sunshine hours per year, which is far more than current total energy consumption. With solar power, every sunray that hits our roof offers a chance to lower the electricity bill and carbon footprint. Solar power generation has emerged as one of the most swiftly growing renewable sources of electricity.

**Solar Panels:** The term solar panel is used for a Photo-Voltaic (PV) module, which is an assembly of photo-voltaic cells framed in setting. The photo-voltaic cells use sunlight as a source of energy to produce electricity. A group of PV modules is known as a PV Panel, and a system of panels is known as array, which dispense solar electricity to electrical equipment.

Solar energy is available nearly everywhere, and will be for another 5 billion years; Solar energy is immediate electricity bill saving; Solar energy is a modular technology; It generates passive income; It is more ecofriendly and promotes better health due to cleaner air, water and soil; It has greater energy security due to reductions in imported fuel; It reduces greenhouse gas emissions, the main cause of disastrous climate change, global warming and severe weather.

The most common application of solar energy is solar water heating systems. The photovoltaic modules use light energy of sun to produce electricity through the photovoltaic effect. Most of modules make use of wafer-based crystalline silicon cells or thin-film cells. The structural component of a module can either be the top layer or the back layer. Most of modules are rigid, but semi-flexible modules are also available. The cells are linked electrically in series, one to another to the required voltage, and then in parallel to increase the amperage. Most solar modules are presently formed of crystalline silicon solar cells of multi-crystalline and mono-crystalline silicon. Besides this, cadmium telluride, CIGS and amorphous silicon are also used for the purpose. The third-generation solar technologies use cutting-edge thin-film cells, which help in comparatively high-efficiency conversion.

**Working of Solar Panels:** Solar panels collect renewable energy of sunlight and convert the same into electricity. Solar panels comprise of several solar cells which are made of layers of silicon, phosphorous, and boron. Solar panels captivate the photons and in doing so instigate an electric current. The subsequent energy produced from photons striking the surface of a solar panel permits electrons to be knocked out of their atomic paths and freed into the electric field produced by the solar cells which later drag these free electrons into a directional current. This process is known as Photovoltaic Effect. An average home has more than enough roof area for installing solar panels to produce solar electricity enough to meet the domestic needs.

**Advantages:** Using solar panels is an economical way to produce electricity for many applications. A solar electric system is possibly less costly. Besides the fact that solar panels make it imaginable to live off-grid, perhaps the greatest benefit is that it is both a clean and renewable source of energy. Solar panels have no moving parts and need little maintenance. They last for decades when properly maintained. Thus, there are several benefits of solar energy in comparison to other forms of power generation:

**Decreased Dependence on Fossil Fuels:** Production of solar energy does not require fossil fuels and hence is not dependent on this insufficient and costly resource. Though there is inconsistency in the amount and timing of sunlight

over the day, season and year, a properly designed system can be more reliable for long-term, fixed price electricity supply.

**Environmental Advantages:** Solar energy has limited impact on environment as compared to other forms of power generation.

**Complementing Production with Requirement:** Solar energy can efficiently complement power supply from a power transmission grid, when the demand of power is at peak.

**Versatility:** As the size and production capacity of a solar electric system are a function of the number of solar units connected, applications of solar technology are freely accessible and adaptable.

**Accommodating Locations:** Solar power generation facilities can be set-up at the customer site, which decreases the essential investments in production and conveyance infrastructure.

**Government Incentives:** A number of countries have set up incentive programs for the development of solar and other renewable energy sources, which allow users to sell electricity at retail prices, promote low interest loans for sponsoring solar power systems.

**Applications:** There are many applications of solar panels or photovoltaics. These can be used in agriculture as a power source for irrigation. In healthcare solar panels can be used to refrigerate medical supplies. PV modules are used in photovoltaic systems with following electric devices:

- Concentrated photovoltaics
- Photovoltaic power stations
- Roof-top solar PV systems
- Solar hybrid power systems
- Solar panels on spacecraft and space stations
- Solar planes
- Solar vehicles
- Solar-powered water purification
- Solar-pumped lasers
- Standalone PV systems

**Limitations in developing Solar Energy:** The sun offers the most abundant, dependable and pollution-free energy source. However, problems, namely the expensive cost and varying accessibility, have prevented it from emerging as most harnessed energy source. What is obstructing solar power has everything to do with price. It is five to eleven times more costly to generate electricity from the sun than from coal, hydro or nuclear sources. The main difficulty is with the cost of the technology. Solar panels use costly semiconductor material to produce electricity directly from sunlight. Semiconductor industrial unit require 'clean' manufacturing environments and are expensive to construct

& maintain. The efficacy of solar cells is only about 22 per cent. The rest of the sunlight that strikes the panel is wasted as heat. More photovoltaic cells that are effective have been discovered but these are still in trial stage. It will probably take time to locate new materials and methods of making solar panels less expensive. Fitting solar panels is expensive and requires skilled experts. Besides this, expensive transmission lines are required to transmit power to a distant place. Maintenance costs are also high since every inch of a solar panel has to be kept clean. Their efficiency drops drastically even when a leaf or a thin film of dust blocks a small section. The main problem with solar power that holds back its use is the fact that energy production takes place only when the sun is shining. Large storage systems need to be developed to provide a constant and reliable source of electricity when the sun is not shining. When solar panels are not generating power, it takes long time to recover their installation and maintenance cost.

**Check Your Progress 3**

- Note:** a) Write your answer in about 50 words.  
b) Check your progress with possible answers given at the end of the unit.

**3. What are the limitations for developing solar energy?**

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**18.4 GREEN PRACTICES AND CONSERVATION  
OF NATURAL RESOURCES**

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Sustenance of human civilization depends on healthy environment, since the living beings are closely linked with the biosphere in which they live. Earth, water, air, plants and animals are the basic components of environment as they provide necessary life supporting conditions. Nowadays, the environmental issues have become one of the major concerns for the entire world. Water pollution, land degradation and deforestation have not only posed serious threats to the quality of life, but have worsened the health status of people. This has increased the incidence of water borne diseases, cardiovascular diseases and cancer. The culture and ethos govern the ecology, environment and human behavior of a nation and the same is reflected in its literature. The Vedic and classical Sanskrit literature are the oceanic treasures full of knowledge, which not only reveal the past but act like a steering beam for future. If the people would have understood and followed the ancient scriptures advocating the necessity and techniques of upholding the ecology and environment, there would not have been the need of framing the modern environmental laws. The Vedic seers have not only explained the significance of protecting the environment but have defined the statutes and penalty for breaking them.

components of environment. According to ancient Indian thought, the nature is composed of five basic elements, i.e., earth, water, fire, air and space. The five elements are all the facets of divinity. Since the five elements are of divine origin, our forefathers have adored them as the personifications of divinity. They worshipped them as goddess earth, goddesses signifying rivers, the fire god, the wind god, and the god of ether. Primarily, our ancestors venerated earth as Mother Earth. Since the food obtained from its lap helped in sustaining life, they worshipped it first. Nature is governed by the principles of reflection, reaction and resounds. Likewise, man, who is the descendant of Mother Nature is guided by these ethics. In ancient times people had special reverence for natural resources, which were conserved in a sustainable manner and there were penalties for harming or polluting them. Land is one of the most important natural resources, which helps in the sustenance of all forms of life. The nature or prakrti, as known in Indian context is believed to be the supreme mother of entire creation. All living beings are totally dependent on what Earth confers in form of food, water, minerals and energy resources. There are some policies and programmes which are meant for the best possible use of land along with sustainable and integrated management of land resources. The prime objective of these initiatives is the management of natural resources and maintenance of ecological balance. Ever since the advent of life on planet earth, water is the source of life and is most indispensable for survival. Even the life is believed to have originated in the water itself. Presence of life on earth was responsible for the origin of life. Water tank is a vital component of every Hindu temple. Conventional belief holds that water of temple tank is sanctified and has cleansing properties. Likewise, the concept of sacred groves originated in the Vedic period, which is one of the instances of traditional conservational measures devised for protecting the forests. Trees like, *Ficus religiosa*, *Ficus benghalensis* and *Saraca asoca* are regarded as sacred trees. In the recent years, various laws and regulations have been made for protecting natural resources. Not only in India, but the efforts have also been made at International level, for the conservation of ecology and environment, e.g., Africa, Sri Lanka and Greece. Numerous National and International organizations are working on conservation of environment, forestry and wildlife. Due to overconsumption, population increase and technological advancements, the biophysical environment is being damaged and various governments have started limiting the activities which cause any environmental damage.

History of environmental laws can be traced back from three-hundred years to early laws of nuisance in England. In late 1800s, the US Congress passed the River and Harbors Act aimed at stopping of water pollution. It was a landmark step meant for protection of natural resources and environment. The environmental movement in the United States, however, did not truly begin in earnest until the early 1970s. Variety of events and with the efforts of educators, it was realized that air, water and land have been damaged seriously and that combined action was required. Man has realized that past sins imposed on environment if not banned in time, can never be repaired.

#### **18.4.1 ORGANIC AGRICULTURE**

Agriculture is the basis of food production and it fulfils the requirement of

food in entire world. Agriculture plays a major role in world's economy, mainly in the developing countries. Rural population is mostly dependent on agriculture, horticulture and livestock rearing. Presently, agriculture and allied sector contributes 15.87 per cent in gross domestic product (GDP) of India which was 56.5 percent during 1950-51. Until man started using the chemicals in farming, the agriculture system was purely organic. According to IFOAM General Assembly, 2008:

Organic agriculture is a production system that sustains the health of soils, ecosystems, and people. It relies on ecological processes, biodiversity and cycles adapted to local conditions, rather than the use of inputs with adverse effects. Organic Agriculture combines tradition, innovation, and science to benefit the shared environment and promote fair relationships and good quality of life for all involved.

Organic agriculture is defined by the use of fertilizers of organic origin, such as compost, green manure, bone meal, etc. and emphasize on techniques such as crop rotation, biological pest control, mixed cropping, etc. Artificial fertilizers were first produced in the mid-19th century. Similar advances occurred in chemical pesticides in the 1940s; however, the new agricultural techniques, while useful in the short-term, had serious long-term side effects such as soil erosion, and decline of soil fertility, and toxic effects on health due to the entry of chemicals in food supply. In the late 1800s and early 1900s, scientists started looking for the alternates to combat the side effects while upholding higher production. There are certain impacts of modern farming, viz.:

- Chemical contamination
- Depletion of energy resources
- Expansion of cultivated area and reduction of forest areas
- Input-output imbalance
- Low productivity
- Reduction in genetic diversity
- Salinity and water-logging

Growing environmental awareness has changed the initially supply-driven organic movement to a demand-driven one. Organic Agriculture methods unite scientific ecological wisdom and contemporary technology with traditional farming practices based on natural biological processes. The unique characteristics of organic agriculture are that it:

- decreases environmental pollution and helps in the regeneration of ecosystem;
- decreases the requirement of inputs;
- distributes the production, suitable to local environment with low-cost production;
- has input optimization with best use/recycling of available resources;
- is harmonious with nature as utilizes the benefit of natural resources,

- flora and fauna by using or giving conducive environment;
- is holistic approach with no imbalance;
- is preventive, caring and proactive approach;
- protects the long-term fertility of soil by upholding soil organic matter levels, with promotion of soil and biological activity; and
- works as mutual service providers for nutrient and pest management;

**Methods of Organic Agriculture:** Organic agriculture involves following techniques:

- **Crop Rotation:** A method to cultivate various crops in the same area, according to different seasons, in a successive manner
- **Green Manure:** Dying plants are uprooted and embedded in soil to make them act as a nutrient for soil to improve its quality
- **Biological Pest Control:** It is a technique in which living organisms are used to control pests
- **Compost:** Organic matter rich in nutrients used as a fertilizer in farming
- **Weed management:** Suppressing the weed rather than eradicating it totally, which is achieved by:

Mulching – a method in which plastic films are used to block the growth of weed

Mowing and cutting – removal of weeds' top growth

**Advantages of Organic Agriculture:** There are certain advantages of organic farming, viz. It:

- conserves soil fertility through execution of suitable conservation practices;
- enhances soil quality;
- increases crop productivity and income;
- is a feasible alternate to conventional farming;
- is a key to sound development and sustainable environment;
- lowers the incidence of pests;
- minimizes the environmental pollution and use of non-conventional natural resources;
- protects the soil from erosion, improves natural resource base and sustains production;
- provides employment opportunities; and
- offers healthy foods

**Key Constraints in Organic Agriculture:** The key constraints in organic agriculture are:



- Failure to meet the export demand
- High input costs
- Inappropriate accounting method
- Insufficient supporting infrastructure
- Lack of suitable agriculture policy, awareness, financial support, quality standards for bio-manures
- Low yields and marketing of organic inputs
- Shortage of biomass

### **18.4.2 AGROFORESTRY**

Agroforestry is an age-old tradition of cultivating food crops, trees and rearing of animals together with harnessing of diverse wood. In the recent years, the forest area has declined and resources have decreased significantly as a result the communities can no longer meet their requirements of fuel wood, fodder, timber, etc. from the forest. Many forest-based industries are facing the problems in getting the raw material. To meet these shortages, farmers have started growing trees along with agriculture, which has given rise to the concept of agroforestry. Thus, agroforestry is collective name for land use systems involving cultivation of trees and crops on the same patch of land. Agroforestry combines production of multiple outputs with conservation of resource base. It is mainly appropriate for low-input situations and fragile environments and is structurally and functionally more complex than monoculture. Agroforestry denotes the practice of agriculture and forest/ horticulture tree on the same land. According to Bene et al. (1977) agroforestry is a sustainable management system for land that increases overall production, combines agriculture crops, forest plants and tree crop and/or animals simultaneously or sequentially and applies management practices that are compatible with the cultural patterns of a local population. Thus, agroforestry system:

- always has two or more outputs;
- has more than one-year cycle;
- has positive and negative interfaces which are displayed among elements (tree, crop);
- involves cultivation of two or more species of plants, at least one of which is woody;
- is more structurally, functionally, economically and ecologically complex than a monocropping system

**Characteristics of Agroforestry:** There are three attributes which all agroforestry system has, these are:

- Adoptability, which means ‘modify’ or ‘change’. Improved or new agroforestry technologies which are started in new areas must adapt to local farming practices;
- Productivity, with an aim to maintain or raise production by increased

output of tree products, improved yields of linked crops, decrease of cropping system inputs, and increased labor efficiency;

- Sustainability, by preserving the production potential of the resource base, mostly through the useful effects of woody perennials on soils

**Prospects of Agroforestry:** Agroforestry can help in improving the productivity of land to meet the demand of ever increasing human and livestock population. Thus, agroforestry helps in providing:

- controlled stream flow, decreased flood hazards and supply of water through decreased run-off and upgrading capture and storage;
- direct cash benefits from sale of tree products and indirect cash benefits from increased output;
- drainage in wet or saline soils by trees with high water necessities;
- fencing, fiber for weaving, fodder for meeting the rural needs, food from trees as fruits, nuts and cereal substitutes;
- fuelwood for direct combustion, pyrolytic conversion products for example charcoal, oil, gas, ethanol, oils, latex and other saps and resins;
- increased food production from crops linked with trees through nitrogen fixation, better access to soil nutrients, better accessibility of nutrients due to high cation-exchange capacity of soil besides its organic matter and mycorrhizal relations
- raw material for industries, viz. paper and pulp industry
- shelter from trees, building materials for shelter, shade trees for people and livestock
- tannins, essential oils and medicinal ingredients
- water conservation by improving soil-moisture holding capacity in rainfed croplands and pastures through better soil structure and micro-climate outcome of trees;
- wind-breaks and shelter-belts for protection of settlements, croplands, pastures and roadways; and
- wood for agricultural implements and various crafts

Thus, by adopting agroforestry man get varied products, viz. fuel, fodder, fruits, fiber, timber, etc.

**Limitations of Agroforestry:** Despite numerous benefits, agroforestry has various limitations:

- Competition for moisture between trees and arable crops is maximum;
- Farmers give more importance to field crops as compared to tree crop;
- Felling of trees damages the crop;
- Interference of trees reduces the crop yield which is lower than the monocropping;

- Longer gestation period delays the earnings to the farmer;
- Some trees act as host to pest that can harm crops;
- Some trees produce chemical exudates which disturbs the growth of crops; and
- Tree canopy absorbs maximum light and gives competition for light

Agroforestry intends to maximize production of biomass of trees and agricultural crops. It provides the farmers with number of farming, forestry and horticultural alternatives and consequently increases income of the farmers per unit of land than monoculture. One of the most important roles of agroforestry in general is to respond to climate change through carbon sequestration in above ground plant biomass and below ground biomass in the soils. Agroforestry reduces the annual rate of deforestation and availability of fuel wood reduces the burden on natural forests. It saves the time that the women have to spent walking long distances for getting fuelwood. Agroforestry contributes in improving the soil health and insurance against climatic hazards, because the trees and shrubs improve the physical properties of soil. Trees enhance water infiltration and water holding capacity of soil thus decreasing the surface runoff and soil erosion. Consequently, trees /shrubs reduce the impact of droughts. The recurrent application of tree biomass raises the soil organic matter which increases water holding capacity of soil and offers beneficial environment for soil microbes and fauna.

### **18.4.3 GOING PAPERLESS**

Paper may seem meaningless, but in reality, it causes ecological damage which has widespread implications. The pulp and paper industry are the third largest industrial polluter to air, water, and land. Right from the beginning, the paper and pulp industry cause damage to environment. Thus, it has become important to go paperless. The paper is obtained from trees, and in reality, 35 per cent of all collected trees, and 40 per cent of all industrial wood is used for manufacturing paper. Since trees absorb CO<sub>2</sub> and release oxygen, they lessen the detrimental effects of greenhouse gases. Furthermore, a single 100-year-old tree can only produce 17 reams of paper, but when it's chopped down it will release 110 lbs of CO<sub>2</sub> into the atmosphere. Thus, this deforestation directly affects the climate and speeds-up the global warming. Deforestation is accountable for global carbon emissions than vehicles. There is a strong link between high levels of atmospheric gas, increased deaths and respiratory diseases. The removal of trees affects the soil quality. Through transpiration, trees control the water level in atmosphere and control water cycle. When there will be less trees, there will be less water. When soils become dry, it undesirably upsets its ability to sustain life. Deforestation raises surface runoff, which causes soil erosion. Removal of trees means destruction of habitats of animals. The paper manufacturing is very harmful to the environment, adjacent communities and staff working in paper industry. Yearly, the world manufactures more than 300 million tons of paper, and one million tons of paper is consumed daily. Paper factories emit significant levels of pollutants. One ton of paper produces 1.5 tons of carbon dioxide. This pollution has adverse effects on nearby communities, and ecosystems. 1.5 cups of water are required to make single sheet of paper,

and nearly 300,000 liters are needed for manufacturing one ton of paper. To produce one ton of paper, 253 gallons of petrol are used. Thus, going paperless is the only way to protect the environment from paper waste, which can save 938 gallons of water; 2.5 trees; 56 gallons of oil; 595 KW energy; 12.15 cubic feet of landfill space and would decrease greenhouse gas emissions by 3.9 billion lbs yearly, which is equal to removing 355,000 cars from the road. Thus, it is important to have paperless working environment, which can be achieved by:

- Avoiding printing of presentations and using notepads;
- Photocopying documents with scanners and phone apps;
- Digitizing business procedures and funding;
- Encouraging durable, recyclable, and high-quality materials;
- Encouraging the concept of recycling and reuse of paper;
- Evolving procurement strategies which promotes prevention of waste;
- Finding paper substitutes, for instance, the use of reusable tissues and cups;
- Investing on energy-efficient office equipment;
- Promoting paper-free internal communications within offices by making use of Microsoft Teams, Google Docs, etc.;
- Reconsidering paperless marketing, through net-shopping, e-books, blog posts, social media posts, videos, and digital advertisement;
- Storing documents and files digitally in the cloud;
- Using electronic communication rather than traditional mail;
- Using electronic signature software that permits legally valid electronic signature documentation; and
- Using recycled paper for the printer

#### **18.4.4 GREEN BUILDINGS**

The advent of green technology has turned out to be beneficial and paved the way for energy-efficient and maintainable buildings, which not only have a lower carbon footprint but reduced environmental impact. Green building takes into account every aspect of construction, viz. structure, design, materials, which are selected to achieve sustainability. The green construction involves various new technologies, which are not only ecofriendly but sustainable. Cool roofs are one of the justifiable green design technologies which reflect heat and keep the buildings at normal temperature by reducing absorption of heat. Electronic Smart Glass is one of the technologies used in sustainable construction, which primarily works in summers to keep away the solar radiation. This technology helps in saving cost of heating, ventilation, and air conditioning. Green insulation is among the highest concerns of buildings and homes. Green insulation offers a way-out of utilizing old and used materials. Rammed earth brick is an age-old construction knowhow which has recently been re-introduced to furnish due to the pressures of environmental sustainability.

Self-powered building is a new concept which is based on zero-energy construction, in which the buildings are constructed in such a way that they are able to produce enough power to support their own energy requirements and even direct extra energy back to the power grid. Sustainable indoor environment technologies ensure the health and safety of residents and are obligatory component of green construction. The materials used include hazard-free elements, non-toxic materials, low unstable emissions, etc. Sustainable resource sourcing, on the other hand ensures the use of construction materials, which can be re-produced, recycled, recyclable, and are obtained from sustainable sources. The application of smart appliances in green buildings emphasizes on the principle of installing energy saving and self-reliant machines, for instance, smart-grid dishwasher, refrigerator and washing machine.

Use of biodegradable materials is an eco-friendly means of sustainable construction. The conventional construction methods result in accumulation of waste and toxic products which require hundreds of years to degenerate. Biodegradable materials, for instance, organic paints, thus, limit the negative environmental impacts. The use of biodegradable materials in foundation, walls and insulators is a part of sustainable construction technologies. In green construction, there is use of functional passive solar systems that absorb solar radiation to cater heating and electricity requirements. Passive solar power makes use of sun rays to warm homes through the planned location of windows and use of heat-absorbing surfaces. Low-energy house and zero-energy building design lessens the energy consumption, for instance, use of wood is a sustainable construction technology as it has a lower energy as compared to steel or concrete. This technology makes use of designs that prevent the escape of air and allows free-flow of air. Water efficiency technologies are part of sustainable construction technologies and include the use of double drainage system, re-use of greywater, rainwater harvesting and water conservation gears.

**Check Your Progress 4**

- Note:** a) Write your answer in about 50 words.  
b) Check your progress with possible answers given at the end of the unit.

**4. Enlist the advantages of organic agriculture.**

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**18.5 LET US SUM UP**

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The growing demand for energy to meet the developmental objectives has not amplified the use of fossils fuels but has increased carbon emissions resulting in global environmental problems. Thus, energy use efficiency must be increased

to regulate the growth of energy and at the same time the input from clean energy sources has to be improved to diminish the harmful environmental impacts of energy use. Green Technology (GT) is an arena of finding innovative ways to make eco-friendly changes in the daily life. It is basically based on the principles which seek to achieve energy independence and promote effective use of resources; conserve and lessen the impact on the environment; enhance the economic development through the use of technology and improve the quality of life. Before the scientific world coined the term Green Technology, the man, has been using the sun, water and wind as a source of energy for achieving various tasks. India has an longstanding storehouse of traditional wisdom that has not only helped in the survival of human civilization in the past but can help in reducing energy consumption and thereby paving the way for the development of green technologies. Green technology denotes clean energy, renewable energy, sustainable energy, waste management and energy conservation.

Opting green technology can bring about economic development. It doesn't release anything detrimental into the environment, protects environment, etc. It provides opportunity to own one's energy generation system. Green Technology is renewable and inexhaustible. It can help in achieving sustainable agriculture by making interventions in Integrated Pest Management, soil conservation, wetland conservation, maintenance of crop diversity, nutrient management, agro-forestry, and marketing of green products. It is expected that advancement in nanotechnology can provide solutions in farming using nano-sensors, nano-pesticides, and low-cost water purification. Some of the Effective Green Technologies are- Emission-free Vehicles; Green-Gas Boilers; Perpendicular gardens and farms; Reducing Industrial Emissions; Solar Energy; Waste Management; Waste-to-Energy; Wastewater Treatment and Waves Energy.

Wind power is cost-effective source of energy. Wind is a natural source of energy and its supply is infinitely available. Wind energy is sustainable, because wind is mostly a type of solar energy. A wind turbine, or a wind energy converter, is a device that converts the kinetic energy of wind into electrical energy. Solar energy, which is radiant light and heat from the sun can be used in promoting a variety of technologies. It is a main source of renewable energy and its technologies are generally described as either passive solar or active solar depending on the way they capture and release solar energy or convert it into solar power. The term solar panel is used for a Photo-Voltaic (PV) module, which is an assembly of photo-voltaic cells framed for fixing. The photo-voltaic cells utilize sunlight to produce direct current electricity. Using solar panels is a practical way to generate electricity for many applications. Organic agriculture is the use of fertilizers of organic origin such as compost, green manure, and bone meal and emphasize on techniques such as crop rotation, biological pest control, mixed cropping, etc. Organic farming conserves soil fertility through execution of suitable conservation practices; enhances soil quality; increases crop productivity and income; minimizes the environmental pollution and the use of non-conventional natural resources; and protects the soil from erosion, improves natural resource base and sustains production. Agroforestry denotes the practice of agriculture and forest/ horticulture tree on the same land and helps in controlling stream flow, decreasing flood hazards.

It provides fuelwood for direct combustion, pyrolytic conversion products for example charcoal, oil, gas ethanol, oils, latex and other burnable saps and resins. Thus, the advent of green technology has turned out to be beneficial and paved the way for energy-efficient and maintainable alternates, which not only have a lower carbon footprint but reduced environmental impact.

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## 18.6 KEY WORDS

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- Agroforestry** : A land use management system where the trees/ shrubs are cultivated around or among crops or pastureland.
- Geothermal Energy** : The thermal energy generated and stored in the Earth.
- Green Building** : A building that in its design, construction or operation, reduces or eliminates negative impacts, and create positive impacts on natural environment.
- Green Technology** : A technology whose use is planned to lessen or reverse the effects of human activity on the environment.
- Organic Farming** : It is a system agricultural production that unites a high level of biodiversity with environmental practices that conserve natural resources
- Solar Energy** : It is a radiant light and heat of sun that is harnessed using a range of ever-evolving technologies such as solar heating, photovoltaics, solar thermal energy, solar architecture, molten salt power plants and artificial photosynthesis.
- Solar Panel** : The devices used to absorb sun rays and convert them into electricity.
- Wind Energy** : It is the use of wind to provide mechanical power through wind turbines to turn electric generators.
- Wind Turbine** : A wind turbine is a device that converts wind's kinetic energy into electrical energy.

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## 18.7 REFERENCES AND SUGGESTED FURTHER READINGS

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## 18.8 TERMINAL QUESTIONS

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1. What are wind turbines? What are the advantages of using wind energy?
2. How can we go paperless?
3. What is organic farming? What are the methods of organic farming? What



are the advantages of organic farming?

4. Describe the concept of Green Buildings.

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## **18.9 ANSWERS TO CHECK YOUR PROGRESS**

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1. Green Technology (GT) is an eco-friendly way that helps in conservation of natural resources and environment.
2. The seven effective green technologies are:
  - Emission-free Vehicles
  - Green-Gas Boilers
  - Perpendicular gardens and farms
  - Self-Sufficient Constructions
  - Waste Management
  - Waste-to-Energy
  - Wastewater Treatment
3. There are certain limitations in developing solar energy. The main difficulty is with the cost of the technology. The efficacy of solar cells is only about 22 per cent. Fitting solar panels is expensive and requires skilled experts and maintenance cost is very high.
4. There are certain advantages of organic farming. It conserves soil fertility through execution of suitable conservation practices; enhances the soil quality; increases crop productivity and income; lowers the incidence of pests; minimizes the environmental pollution; prevents soil erosion improves natural resource base and sustains the production.