- **Sustainable Development:**

✓ Sustainable development is **defined** as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs". It also looks at the equity between countries and continents, races and classes, gender and ages. It includes social development and economic opportunity on one hand and the requirements of environment on the other.

✓ The essence of this form of development is a stable relationship between human activities and the natural world, which does not diminish the prospects for future generations to enjoy a quality of life at least as good as our own.

✓ The **aim** of sustainable development is to balance our economic, environmental and social needs, allowing prosperity for now and future generations. Sustainable development consists of a long-term, integrated approach to developing and achieving a healthy community by jointly addressing economic, environmental, and social issues, whilst avoiding the over consumption of key natural resources.

✓ The **objective** of sustainable development is to gradually create a world in which an increasingly large percentage of people are able to live in acceptable circumstances where, at the very least, they have good healthcare, nutrition, housing, education and other things.

✓ There are **four dimensions** to sustainable development – **society, environment, culture and economy** – which are intertwined, not separate. Sustainability is a paradigm for thinking about the future in which environmental, societal and economic considerations are balanced in the pursuit of an improved quality of life. **For example**, a prosperous society relies on a healthy environment to provide food and resources, safe drinking water clean and air for its citizens.

✓ The **principle** of the four pillars of sustainability states that for complete sustainability problems to be solved in relation to all four pillars of sustainability and then need be maintained. Although in some cases these may overlap, it is important to identify the specific type of green business to focus on, as the four types present unique characteristics. Businesses need to make a strategic decision about it so as to effectively incorporate the chosen approach into their policies and procedures.

✓ The key principle of sustainable development underlying all others is the integration of environmental, social, and economic concerns into all aspects of decision making.

- **Principles of Sustainable Development:**

There are a few principles related to sustainable development. These can be summarized as follows:

1) **Conservation of our ecosystem:** The ultimate motive of sustainable development is to protect the ecosystem. Preservation of earth and its resources is essential.
2) **Development of society:** Sustainable development focuses on developing society by creating equal opportunities for everyone. From creating jobs to the reliable health system, everything gets included under this principle
3) **Conservation of biodiversity:** Natural resources are already limited. Exploiting these further to meet our needs is not acceptable. Protecting our biodiversity is essential to protect our earth from further damage.

4) **Protecting human resources:** People play an important role in protecting and conserving society. Human resources can be used to save the earth. Hence, sustainable development considers human resource an essential aspect of it.
5) **Conservation of cultural heritage:** Sustainable development highlights the conservation of cultural heritage. Different cultures have an invaluable contribution to society. By conserving the same, a sustainable society can be promoted.
6) **Creating a community within the capacity of Earth:** Sustainable development is all about developing a community within the carrying capacity of Earth. Our planet has its own capacity and going beyond it can have a severe impact on the environment (as we are witnessing in the present day). Earth has limited resources and it cannot be used to meet the unlimited requirements. So, sustainability is all about ensuring that our needs meet the producing capacity of our planet.

- **Implications of population growth:**

✓ **Farming impacts**: A growing agricultural base to feed an expanding world population comes with its own complications. As the global population increases, more food is needed. Such measures may be met through more intensive farming, or through deforestation to create new farm lands, which in turn can have negative outcomes. Agriculture is responsible for about 80 percent of deforestation, worldwide.
✓ The yield of existing farmland can be increased through intensive farming to feed our rapidly growing population. This approach is characterized by reliance on mechanization, pesticides and chemical fertilizers. Such practices can be associated with soil erosion or depletion.
✓ According to the World Wildlife Fund, the land used and abandoned in the last 50 years globally may be equal to the amount of land used today.
✓ **Deforestation:**Deforestation in turn leads to a reduced ability to capture CO2, thus exasperating the greenhouse gas problem. Tropical rainforests in South America are responsible for producing 20 percent of the Earth's oxygen.
✓ Deforestation is also strongly associated with loss of habitat and extinctions. Agriculture, as mentioned above, is responsible for about 80% of global deforestation. Another 14 percent is attributed to logging, 5 percent to firewood collection, and the balance resulting from other causes.
✓ Human population increase is related to all of these deforestation pressures. More people means we need more food, more wood products, and more firewood.

✓ **Eutrophication:** Agricultural runoff is one of the main causes of eutrophication, the presence of excessive nutrients in bodies of water, such as large pockets like the Dead Zone of the Gulf of Mexico. Worldwide, there are more than 400 marine 'dead zones' caused by eutrophication, collectively covering an area six times the size of Switzerland.

✓ Eutrophication causes the dense growth of plant life that consumes oxygen, resulting in the death of aquatic animals. Other major sources of eutrophication are industry and sewage disposal--both related to population growth.

- ✓ **Loss of Fresh Water:**While there is plenty of water on the planet, it is very much a scarce resource. Only 2.5 percent of water resources are fresh water, and just a small fraction of that is available as unpolluted drinking water.

- ✓ One of the byproducts of population growth has been stress on freshwater supplies. "Water stressed" is defined as a case of demand exceeding the supply of suitable water available. A commentator expects 2/3 of the world's population to be living with water shortages by 2025, which he attributes to population growth.

- ✓ **Global Warming:**Human population growth and climate change have grown hand in hand as the use of fossil fuels has exploded to support industrialized societies.

- ✓ "More people means more demand for oil, gas, coal and other fuels mined or drilled from below the Earth's surface that, when burned, spew enough carbon dioxide (CO_2) into the atmosphere to trap warm air inside like a greenhouse," notes Scientific American. Most fossil fuel consumption comes from developed countries. It is a sobering thought that most developing nations aspire to similar industrial economies as they experience economic growth, which further escalates CO_2 emissions into the atmosphere.

- ✓ **Deforestation** is another important component of greenhouse gas emissions. Globally, forests store more than twice the amount of carbon dioxide than is found in the atmosphere. As forests are cleared and burned, that CO_2 is released into the atmosphere, accounting for an estimated 25 percent of total greenhouse gas production.

- **Limits to Growth**

- ✓ The Limits to Growth (LTG) is a 1972 report on the exponential economic and population growth with a finite supply of resources, studied by computer simulation.

- ✓ Growth is an increase in some quantity over time. Growth is not Development. Development is to become more mature, elaborate. Growth by itself does not sustain communities, in fact it can destroy them. Growth is by itself neither good nor bad. It depends on what is growing and when. Nothing grows forever.
- ✓ To overshoot means to go too far, to grow so large so quickly that limits are exceeded . When an overshoot occurs, it induces stresses that begin to slow and stop growth. The cause for overshoot and collapse are always the same .First, there is growth, acceleration, rapid change. Second, the growth drives a depletion of some resource required for the growth or an increase in some resource that harms the growth. Third this dynamics causes a contraction, deceleration or decay resulting in a collapse.

- ✓ Population and industrial growth are inherently exponential; and that exponential growth takes one to any existing limit quickly, whatever its magnitude .Global society will most likely adjust to limits by overshoot and collapse and not by S- shaped growth. However sustainable development is possible, if important changes are made. Politics and the market are inherently unsuited to adopt constructive policies that can lead to sustainable development.

- ✓ Energy production refers to forms of primary energy--petroleum (crude oil, natural gas liquids, and oil from nonconventional sources), natural gas, solid fuels (coal, lignite, and other derived fuels), and combustible renewables and waste--and primary electricity, all converted into oil equivalents.

- **Energy Management:**

- ✓ Energy management is the process of tracking and optimizing energy consumption to conserve usage in a building.
- ✓ There are **few steps** for the process of energy management:
  1) Collecting and analyzing continuous data.
  2) Identify optimizations in equipment schedules, set points and flow rates to improve energy efficiency.
  3) Calculate return on investment. Units of energy saved can be metered and calculated just like units of energy delivered.
  4) Execute energy optimization solutions.
  5) Repeat step two to continue optimizing energy efficiency.

- **Benefits of Energy Management:** Energy management offers multiple benefits to organizations which include:
- ✓ Cutting costs through competitive procurement and strategically decreasing consumption.
- ✓ Reducing greenhouse gas emissions for greater corporate social responsibility
- ✓ Tracking your utility costs to prepare more accurate budgets and gain greater insight into your operational costs.
- ✓ Reducing reliance on supply chains that are inherently volatile
- ✓ Therefore, not only does energy management offer short-term benefits, it also can prepare your business to effectively plan for the future by gaining greater insight into the needs of your organization.

- **Energy Resources: An Overview**
- ✓ Energy is defined by physicists as the capacity to do work. Energy is found on our planet in a variety of forms, some of which are immediately useful to do work, while others require a process of transformation.
- ✓ The sun is the primary energy source in our lives. We use it directly for its warmth and through various natural processes that provide us with food, water, fuel and shelter. The sun's rays power the growth of plants, which form our food material, give off oxygen which we breathe in and take up carbon dioxide

that we breathe out. Energy from the sun evaporates water from oceans, rivers and lakes, to form clouds that turn into rain.

- ✓ Today's fossil fuels were once the forests that grew in prehistoric times due to the energy of the sun. Chemical energy, contained in chemical compounds is released when they are broken down by animals in the presence of oxygen.
- In India, manual labour is still extensively used to get work done in agricultural systems, and domestic animals used to pull carts and ploughs. Electrical energy produced in several ways, powers transport, artificial lighting, agriculture and industry. This comes from hydel power based on the water cycle that is powered by the sun's energy that supports evaporation, or from thermal power stations powered by fossil fuels.

- **Importance of Energy Resources:** The Importance of Energy Resources is as follows:

- ✓ Power is the main input for agriculture and industry.
- ✓ Energy sources are the backbone of economic development.
- ✓ The resources which are widely used and constitute the major source of energy are called conventional resources of energy.
- ✓ Energy is required to run machines and vehicles, to cook our food, to light our streets, to warm or cool our houses and offices, and to recycle various materials for further use.
- ✓ Energy resources are the chief sources of fuel and power in India.

- **Types of Energy:**

1. **Renewable Energy:-**

- ✓ Renewable energy systems use resources that are constantly replaced and are usually less polluting. We also get renewable energy from burning trees and even garbage as fuel and processing other plants into bio fuels. One day, all our homes may get their energy from the sun or the wind. Your car's gas tank will use bio fuel. Your garbage might contribute to your city's energy supply.
- ✓ Renewable energy technologies will improve the efficiency and cost of energy systems. We may reach the point when we may no longer rely mostly on fossil fuel energy.
- ✓ The key characteristics of renewable energies is that the energy sources are continually available, still some cases such as with hydro power and biomass, continuing availability requires good management – **for example** tree planting or river management. Other renewable like solar and wind power are available for the foreseeable future without any human intervention.
- ✓ Renewable energy **sources** include: Hydro Power, Solar power, Wind power, geothermal (energy from the heat inside the earth), bio-fuels etc.

2. **Non-Renewable Energy:-**

- ✓ To produce electricity from non-renewable resources the material must be ignited. The fuel is placed in a well contained area and set on fire. The heat generated turns water to steam, which moves through pipes, to turn the blades of a turbine. This converts magnetism into electricity, which we use in various appliances.

- ✓ These consist of the mineral based hydrocarbon fuels coal, oil and natural gas, that were formed from ancient prehistoric forests. These are called 'fossil fuels' because they are formed after plant life is fossilized.
- ✓ At the present rate of extraction there is enough coal for a long time to come. Oil and gas resources however are likely to be used up within the next 50 years. When these fuels are burnt, they produce waste products that are released into the atmosphere as gases such as carbon dioxide, oxides of sulphur, nitrogen, and carbon monoxide, and all causes of air pollution.
- ✓ These have led to lung problems in an enormous number of people all over the world, and have also affected buildings like the Taj Mahal and killed many forests and lakes due to acid rain.
- ✓ Many of these gases also act like a green house letting sunlight in and trapping the heat inside. This is leading to global warming, a raise in global temperature, increased drought in some areas, floods in other regions, the melting of icecaps, and a rise in sea levels, which is slowly submerging coastal belts all over the world.
- ✓ Warming the seas also leads to the death of sensitive organisms such as coral. Non-renewable types of energy include all the fossil fuels – coal, oil, gas and their derivatives such as petrol and diesel. The non-renewable are finite in supply because their rate of formation is so low that they are, in reality, finite sources.

- **Fossil Fuel and its uses:** Fossil fuels are non – renewable as they take millions of years to get renewed. They are formed from the prehistoric remains of plants and animals.

- ✓ Fossil fuel, any of a class of hydrocarbon-containing materials of biological origin occurring within Earth's crust that can be used as a source of energy.
- ✓ The **three** forms of fossil fuels are **natural gas, coal and oil/ petroleum**. The most widely used fossil fuel is petroleum. This word is derived from a Latin word where "petro" means rock and "leum" means oil. Around 40% of electricity generated worldwide is through coal and it is abundant resource.
- ✓ Natural gas is mostly majorly used in industrial sector as it more efficient and convenient source of energy.
- ✓ One of the main by-products of fossil fuel combustion is carbon dioxide (CO_2). The ever-increasing use of fossil fuels in industry, transportation, and construction has added large amounts of CO_2 to Earth's atmosphere.

- **Uses of fossil fuels:**

Three types of fossil fuels exists in three different forms. Oil being in liquid form. Coal being in solid form and natural gas being in gaseous form. Below are the fossil fuels uses in different fields:

- ✓ **Uses of oil:**

Crude oil or petroleum is also called as "black gold". There are various uses of petroleum. It is used in the generation of electricity, used in transportation as fuel for automobiles and jets. The by-product of oil is used to produce chemicals, plastics, lubricants, tars, waxes, medicines etc. Also, many of the fertilizers, as well as pesticides, are made from either oil or its by product.

- ✓ **Uses of coal:**

  Coal is a solid state fossil fuel. It consists of five elements. They are sulphur, nitrogen, hydrogen, carbon and oxygen. Three different types of coal with different energy properties are anthracite, bituminous and lignite. Anthracite is hard with more carbon than the other two and has the highest energy. Coal could exist for 200 years more. It is mostly extracted from the mines.

  Coal use has almost doubled since the 20th century. Many countries cannot afford natural gas or oil as they are expensive, and so they depend on coal for energy. It is used in the generation of electricity. Also, used in electrical utilities, and products like dyes, aspirins, soap, fibres, plastics and solvents have coal or coal by product. It is used in steel industry, pharmaceutical industry, cement manufacture, manufacturing of paper etc.

- ✓ **Uses of natural gas:**

  It is a gaseous fuel and primarily consists of methane. It is much cleaner than oil and coal. It is used in air conditioning, cooking appliance like fuel stoves and heat homes and buildings, heating water etc. It also provides electricity and is used in industries like steel foundries, glass foundries other manufacturing, aluminium smelters. It also produces paints, fertilizers, plastics and dyes. It is also used in transportation as CNG or LNG.

- **Environmental Impacts of Fossil Fuels in General:** Extraction of fuel by mining, drilling, quarrying and/or excavation leads to significant impacts on the surrounding environment and landscape (habitat modification and destruction, pollution etc.)
- ✓ Spoil and solid wastes from mining and extraction have both visual and environmental impacts.
- ✓ Wastewater and leachates from mining, drilling and excavation, and gas leaks from pipelines can pollute surrounding waters, air and land.
- ✓ Purification or modification of raw products for use as fuels requires energy, and may lead to secondary sources of pollution.
- ✓ Transportation of fuels to energy production sites uses fuel (causes air pollution) and possibly a pollution risk, e.g. oil tankers are at risk from accidents and may lead to oil spills at sea.
- ✓ Combustion of fuels to produce energy leads to air pollution (carbon, nitrogen and sulphur oxides) and in some cases, the production of solid wastes (in the form of ash).

- **Advantages and Disadvantages of Fossil Fuels**
- ✓ **Advantages:**

1) Fossil fuels can generate a large amount of electricity at a single location.
2) They can be found very easily.
3) They are cost-effective.
4) Transportation of oil and gas can be done easily through pipelines.
5) They have become safer over time.
6) Despite being a finite resource, it is available in plenty.

✓ **Disadvantages:**

1) Fossil fuels emit carbon dioxide when burnt which is a major greenhouse gas and the primary source of pollution. This has contributed to global warming.
2) They are a non-renewable resource, i.e., once used they cannot be replaced.
3) Combustion of fossil fuels makes the environment more acidic. This has led to unpredictable and negative changes in the environment.
4) Harvesting of fossil fuels also causes fatal diseases among the people. For eg., the coal miners often suffer from Black Lung Disease. The natural gas drillers are constantly exposed to chemicals and silica which is dangerous for their health.

- **Energy Balance:**

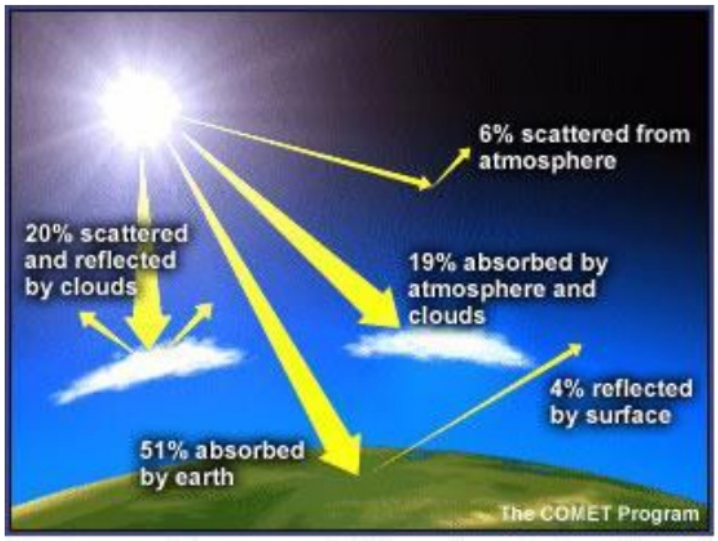
✓ The earth-atmosphere energy balance is the balance between incoming energy from the Sun and outgoing energy from the Earth. Energy released from the Sun is emitted as shortwave light and ultraviolet energy. When it reaches the Earth, some is reflected back to space by clouds, some is absorbed by the atmosphere, and some is absorbed at the Earth's surface.

✓ Earth's Energy balance describes how the incoming energy from the sun is used and returned to space. If incoming and outgoing energy are in balance, the earth's temperature remains constant.

✓ However, since the Earth is much cooler than the Sun, its radiating energy is much weaker (long wavelength) infrared energy. We can indirectly see this energy radiate into the atmosphere as heat, rising from a hot road, creating shimmers on hot sunny days.

✓ The earth-atmosphere energy balance is achieved as the energy received from the Sun balances the energy lost by the Earth back into space. In this way, the Earth maintains a stable average temperature and therefore a stable climate.

✓ Essentially 100% of the energy that fuels the earth comes from the sun. To maintain a constant global average temperature, all of the sun's radiation that enters Earth's atmosphere must eventually be sent back to space. This is achieved through Earth's energy balance. Below figure depicts how the energy from the sun is absorbed, reflected, and emitted by the earth.



- ✓ 100% of the energy entering earth's atmosphere comes from the sun.

- ✓ 50% of the incoming energy is absorbed by the earth's surface i.e. the land and oceans.

- ✓ 30% is directly reflected back to space by clouds, the earth's surface and different gases and particles in the atmosphere (the earth's albedo is 0.3 on average).

- ✓ 20% is absorbed by the atmosphere and clouds.

- ✓ The 70% of the sun's energy that is absorbed by the earth's surface, clouds, and atmosphere causes warming. Any object or gas that has a temperature emits radiation outward, and this is ultimately re-radiated back into space. This occurs 24 hours a day, and the energy is emitted as long wave radiation due to the characteristic temperatures of the earth and atmosphere.

- ✓ Most of the energy emitted from the earth's surface does not go directly out to space. This emitted energy is reabsorbed by clouds and by the gases in the atmosphere.

- ✓ The majority of the energy is reabsorbed by the greenhouse gases such as methane, nitrous oxide, ozone, carbon dioxide and water vapor. These gases constantly emit the sun's energy back into the atmosphere and keep the earth a habitable temperature. Eventually, most of the energy makes its way back out to space and Earth's energy balance is fairly well maintained.

- There are **three** main factors deciding the climate of a planet:
- ✓ **Solar input**- The total solar influx, depending on distance from the sun, angle of the planet's axis and solar activity
- ✓ **Albedo** - or reflections of solar rays from the Earth and back into space
- ✓ **Chemical composition** of the atmosphere
- ✓ There are several other factors and mechanisms having impacts as well, such as changes in ocean currents and maybe cosmic radiation, but as a rule they are not the primary forcing factors, but rather parts of feedback systems that enforce the trend in either cooling or warming the planet.

- **<u>How does this relate to agriculture?</u>**
- ✓ The daily change of temperature and the seasonal changes of weather are both effects of the delicate balance of incoming sunlight and outgoing long wave radiation. On a clear and windless day, the temperature will rise following the course of the sun. But even after noon, when solar radiation begins to decline, temperatures will continue to rise because the land is trying to reach a balance of incoming and outgoing energy.
- ✓ In winter when days are short, the peak temperatures can occur 2-3 hours after noon. In summer when days are longer, it can be 4 to 5 pm before the highest temperatures are reached. The coolest temperatures usually occur just around sunrise when no sunlight has hit the ground for several hours. Planning fieldwork late in the afternoon is more likely to result in ill effects of high temperatures and heat exhaustion in summer because of this thermal lag.

- ✓ The seasons also reflect the attempts of the earth to balance incoming and outgoing energy on a larger scale. Just like the lag of temperatures on a day, the hottest summer temperatures occur after the maximum sunlight has been reached. In the Southeast this generally happens about a month after the summer solstice (when the sun is highest in the sky at noon). Similarly, the coldest temperatures tend to occur about a month after the winter solstice in December

- **Energy Production:**
- ✓ Energy production refers to how much primary energy a country extracts from nature. This is the total of all of the harvested primary fuels and primary energy flows. Note production ignores both imports and exports, and sums up what's extracted from nature.
- ✓ Energy production would include:
- ✓ Any coal, oil or natural gas that is extracted from the ground in that country (but not the fossil fuels that are imported.
- ✓ Any hydropower, wind, geothermal, tidal or solar power extracted from nature.
- ✓ Electricity from nuclear power plants, rather than the energy held in uranium that's been mined because there's so much more energy in the uranium than any of the other sources. The accounting for nuclear power is done differently, so only the electricity is considered.
- ✓ Energy development is the field of activities focused on obtaining sources of energy from natural resources. These activities include production of conventional, alternative and renewable sources of energy, and for the recovery and reuse of energy that would otherwise be wasted. Energy conservation and efficiency measures reduce the demand for energy development, and can have benefits to society with improvements to environmental issues.
- ✓ Societies use energy for transportation, manufacturing, illumination, heating and air conditioning, and communication, for industrial, commercial, and domestic purposes. Energy resources may be classified as primary resources, where the resource can be used in substantially its original form, or as secondary resources, where the energy source must be converted into a more conveniently usable form.
- ✓ Energy has been the engine of nations' development, and this has driven mankind towards growing energy needs, in particular for transportation, agricultural and industrial activities and buildings.
- ✓ Energy for transportation is based on oil derived fuel, whereas energy in buildings consists mainly of electricity, which is produced from fossil fuels, nuclear power and/or from renewable energy sources, such as hydro and solar. Agricultural and industrial activities use a combination of fossil fuels and electric energy.
- ✓ To increase the sustainability of energy production and efficient energy use, it is urgent that better monitoring and control systems are used, and increase the energy production from renewable sources. This drives the energy sector towards the need for Life Cycle Analysis of energy processes to support the selection and implementation of more sustainable energy systems, as well as to develop better and more intelligent electric energy grids, where storage energy systems plays an essential role.

- ✓ **Developing energy storage systems** - Energy storage systems are vital to maximize the production and utilization of energy produced from existing and/or future resources. In particular, many of the more relevant issues and problems troubling current resources can be significantly reduced or even solved by selecting the more adequate energy storing systems and/or technologies.

- ✓ A wide variety of energy storage systems are used today in a variety of different situations and backgrounds, including our daily lives, as for example automobiles have a lead acid battery that stores the energy needed to start the engine.

- ✓ Many different methods are available based in different physical and/or chemical phenomena. Examples include mechanical energy storage, such as compressed air and hydroelectric energy storage, thermal such as phase change materials or underground thermal storage, electrochemical such as batteries, chemical such as hydrogen, among others. The various methods differ by their capacity, energy density, time frame in which the energy can be stored, potential applications of the stored energy.
- ✓ The United States exports more coal to other countries than it imports from other countries. The United states imports and exports steam coal and metallurgical coal. Steam coal can be used for electricity generation and metallurgical coal can be used for steel production.

- ✓ **How does oil affect the environment?**
  Crude oil is used to make the petroleum products we use to fuel airplanes, cars, and trucks; to heat homes; and to make products such as medicines and plastics. Although petroleum products make life easier, finding, producing, and moving crude oil may have negative effects on the environment.
- ✓ Technology helps reduce the effects of drilling for and producing oil
- ✓ Exploring and drilling for oil may disturb land and marine ecosystems. Seismic techniques used to explore for oil under the ocean floor may harm fish and marine mammals.
- ✓ Drilling an oil well on land often requires clearing an area of vegetation. However, technologies that significantly increase the efficiency of exploration and drilling activities also reduce effects on the environment.
- ✓ Satellites, global positioning systems, remote sensing devices, and 3-D and 4-D seismic technologies make it possible to discover oil reserves while drilling fewer exploratory wells. The use of horizontal and directional drilling makes it possible for a single well to produce oil from a much larger area, which reduces the number of wells necessary to develop an oil resource.

Trade in India:

- ✓ Presently, India exports electricity to Nepal, Bangladesh and Myanmar, while India imports power from Bhutan. However, sometimes India also exports power to Bhutan during lean hydro season.
- ✓ India has signed Memorandum of Understanding with Bhutan, Bangladesh, Nepal, and Myanmar to inter-alia improve power connectivity with these neighboring countries. The Ministry of Power issued the Guidelines on Cross Border Trade of Electricity on 05.12.2016, which was subsequently substituted by the 'Guidelines for Import/Export (Cross Border) of Electricity-2018' issued on 18.12.2018, to promote cross border trade of electricity with neighboring countries. Further to improve power connectivity with neighbouring countries, following interconnections are at various stages of implementation:-

- ✓ 400kV operation of Muzaffarpur (India) – Dhalkebar (Nepal) 400kV D/c line (operated at 220kV)
- ✓ Baharampur (India) – Bheramara (Bangladesh) 2nd 400kV D/c line
- ✓ Alipurduar (India) – Jigmeling (Bhutan) 400kV D/c (Quad) line
- ✓ Gorakhpur (India) – New Butwal (Nepal) 400kV D/c (Quad) line
- ✓ Sitamarhi (India) – Dhalkebar (Nepal) – Arun-3 HEP (Nepal) 400kV D/c (Quad) line
- ✓ Nepal and Bangladesh are not using Indian Transmission Grid to trade power between two countries.
- ✓ The trading arrangement for import/export of electricity with neighboring countries, including Nepal, Bhutan and Bangladesh would facilitate regional trade in power and help in meeting the requirement of power in the respective countries thereby moving towards greater energy security in the region.
- ✓ India already has regional power system integration with Bangladesh, Bhutan and Nepal through high voltage synchronous (Alternating Current) and asynchronous (High Voltage Direct Current) connections. Learning from the best practices of advanced nations, the latest technologies like STATCOM, Voltage Source Converter based HVDC system, etc. have been deployed in the Indian grid as a continuous measure of improvement for facilitating power transfer with reliability amongst regional neighbouring countries.
- ✓ Electricity is bought, sold and traded in wholesale and retail markets, which operate similarly to wholesale and retail markets for other products. The purchase and sale of electricity to resellers (entities that purchase goods or services with the intention to resell them to someone else) is done in the wholesale market, while the purchase and sale of electricity to consumers is done in the retail market.
- ✓ Organized wholesale electricity markets were created to address ever-increasing electricity prices and to encourage innovation through free-enterprise competition.