UNIT 1

Introduction to Energy Science

Q.1. What is Environment. How can you say it constitutes a "life supporting system"?

Ans. The natural environment encompasses all living and non-living things occurring naturally on Earth or some region thereof. It is an environment that encompasses the interaction of all living species. The concept of the *natural environment* can be distinguished by components:

- Complete ecological units that function as natural systems without massive human intervention. including all vegetation, microorganisms, soil, rocks, atmosphere, and natural phenomena that occur within their boundaries.
- Universal natural resources and physical phenomena that lack clear-cut boundaries, such as air, water, and climate, as well as energy, radiation, electric charge, and magnetism, not originating from human activity.

The atmosphere of the Earth serves as a key factor in sustaining the planetary ecosystem. The thin layer of gases that envelops the Earth is held in place by the planet's gravity. Dry air consists of 78% nitrogen, 21% oxygen, 1% argon and other inert gases, such as carbon dioxide. The remaining gases are often referred to as trace gases, among which are the greenhouse gases such as water vapour, carbon dioxide, methane, nitrous oxide, and ozone. Filtered air includes trace amounts of many other chemical compounds. Air also contains a variable amount of water vapour and suspensions of water droplets and ice crystals seen as clouds. Many natural substances may be present in tiny amounts in an unfiltered air sample, including dust, pollen and spores, sea spray, volcanic ash, and meteoroids. Various industrial pollutants also may be present, such as chlorine (elementary or in compounds), fluorine compounds, elemental mercury, and sulphur compounds such as sulphur dioxide [SO_2].

The ozone layer of the Earth's atmosphere plays an important role in depleting the amount of ultraviolet (UV) radiation that reaches the surface. As DNA is readily damaged by UV light, this serves to protect life at the surface. The atmosphere also retains heat during the night, thereby reducing the daily temperature extremes.

Evidence suggest that life on Earth has existed for about 3.7 billion years. All known life forms share fundamental molecular mechanisms. In biology, the science of living organisms, "life" is the condition which distinguishes active organisms from inorganic matter, including the capacity for growth, functional activity and the continual change preceding death. A diverse array of living organisms (life forms) can be found in the biosphere on Earth, and properties common to these organisms—plants, animals, fungi, protists, archaea, and bacteria—are a carbon- and water-based cellular form with complex organization and heritable genetic information. Living organisms undergo metabolism, maintain homeostasis, possess a capacity to grow, respond to stimuli, reproduce and, through natural selection, adapt to their environment in successive generations.

Q.2. what are the Conventional sources of energy for the humanity?

Ans. The conventional sources of energy are generally non-renewable sources of energy, which are being used since a long time. These sources of energy are being used extensively in such a way that their known reserves have been depleted to a great extent.

At the same time it is becoming increasingly difficult to discover and exploit their new deposits. It is envisaged at known deposits of petroleum in our country will get exhausted by the few decades and coal reserves are expected to last for another hundred years. The coal, petroleum, natural gas and electricity are conventional sources of energy.

Coal: Coal is one of the most important sources of energy and is being used for various proposes such as heating of housed, as fuel for boilers and steam engines and for generation of electricity by thermal plants.

Coal has also become a precious source of production of chemical of industrial importance coal is and will continue to be the mainstay of power generation in India. It constitutes about 70% of total commercial energy consumed in the country.

Oil and Natural Gas: Like coal, petroleum is also derived from plants and also from dead animals that lived in remote past. Natural gas has also been produced in the Earth's curst by the similar process as petroleum and this is also a combustible fuel.

The exploitation of oil on a large scale started after 1960, the year when the first commercial well is reported to have come into existence. In India, efforts made by the Oil and Natural Gas Corporation since the late 1950s have led to the identification of a number of oil and gas deposits both offshore and onshore.

Natural gas is also emerging as an important source of energy in India's commercial energy scene in view of large reserves of gas that have been established in the country, particularly, in South Basin off west coast of India. Natural gas in also making significant contribution to the household sector.

About 30% of the country's output of LPG comes from this source. About three- fourths as the total gas comes from Mumbai high and rest is obtained from Gujarat, Andhra Pradesh, Assam Tamil Nadu and Rajasthan. The Oil and Natural Gas Corporation has made a significant hydro carbon finding and Reliance Industries struck gas off the Orissa coast in Bay of Bengal.

Electricity: It is another conventional source of power, which is playing a barometer of a nation's economic well-being. Availability of abundant electricity means unrestricted growth of industries, transport and agriculture.

There are various sources from which electricity is being produced. Depending upon raw material used, there are three types of electricity (1) Hydroelectricity (ii) Thermal electricity (steam, gas, oil) (iii) Nuclear electricity.

Q.3. What are the different energy resources that exist on our planet?

Ans. There are many different energy resources on our planet, but they are all classified into two primary groups – renewable energy resources, and non-renewable energy resources. Some energy resources generate additional energy, which is then converted into electrical energy. Examples of these types of energy include geothermal energy and hydro electric energy.

Renewable energy resources are energy resources that are directly available, immediately accessed, and can be consistently replaced. In other words, renewable energy resources are energy resources that replace, or renew themselves and that will never run out. Solar energy, energy that is harnessed

form the sun, is a good example of one of many renewable energy resources, because we will never run out of the sun's rays or its power. Other examples of renewable energy sources include wind energy, water energy, and wave energy.

Nonrenewable energy resources on the other hand are just the opposite. These energy resources are as the name implies, non-renewable. Our Earth is fixed with a finite amount of these energy resources, and once we run out, we will not be able to use those energy resources ever again. Fossil fuels, coal, oil, and gas, are all examples of non-renewable energy resources.

India is facing an acute energy scarcity which is hampering its industrial growth and economic progress. Setting up of new power plants is inevitably dependent on import of highly volatile fossil fuels. Thus, it is essential to tackle the energy crisis through judicious utilization of abundant the renewable energy resources, such as biomass energy, solar energy, wind energy and geothermal energy. Apart from augmenting the energy supply, renewable resources will help India in mitigating climate change. India is heavily dependent on fossil fuels for its energy needs. Most of the power generation is carried out by coal and mineral oil-based power plants which contribute heavily to greenhouse gases emission.

Q.4. What do you understand by Non-Conventional Energy sources? Explain a few.

Ans. Energy generated by using wind, tides, solar, geothermal heat, and biomass including farm and animal waste as well as human excreta is known as non-conventional energy. All these sources are renewable or inexhaustible and do not cause environmental pollution. Moreover they do not require heavy expenditure.

1. **Wind Energy:** Wind power is harnessed by setting up a windmill which is used for pumping water, grinding grain and generating electricity. The gross wind power potential of India is estimated to be about 20,000 MW, wind power projects of 970 MW capacities were installed till March. 1998. Areas with constantly high speed preferably above 20 km per hour are well-suited for harnessing wind energy.
2. **Tidal Energy:** Sea water keeps on rising and falling alternatively twice a day under the influence of gravitational pull of moon and sun. This phenomenon is known as tides. It is estimated that India possesses 8000-9000 MW of tidal energy potential. The Gulf of Kuchchh is best suited for tidal energy.
3. **Solar Energy:** Sun is the source of all energy on the earth. It is most abundant, inexhaustible and universal source of energy. AH other sources of energy draw their strength from the sun. India is blessed with plenty of solar energy because most parts of the country receive bright sunshine throughout the year except a brief monsoon period. India has developed technology to use solar energy for cooking, water heating, water dissimilation, space heating, crop drying etc.
4. **Geo-Thermal Energy:** Geo-thermal energy is the heat of the earth's interior. This energy is manifested in the hot springs. India is not very rich in this source,
5. **Energy from Biomass:** Biomass refers to all plant material and animal excreta when considered as an energy source. Some important kinds of biomass are inferior wood, urban waste, bagasse, farm animal and human waste.

Q.5. Discuss advantages and disadvantages of renewable sources of energy.

Ans. Advantages of renewable energy:

The main advantage is the fact that they are renewable. We will never run out of sources of renewable energy (at least in our lifetimes, as long as humans will exist)

- **Solar energy:** The sun will always be there, and in abundance - the amount of solar energy intercepted by the Earth every minute is greater than the amount of energy the world uses in fossil fuels each year.
- **Wind energy:** The wind will always exist - The energy in the winds that blow across the United States each year could produce more than 16 billion GJ of electricity - more than one and one-half times the electricity consumed in the United States in 2000.
- **Tidal energy:** The moon which provides the forces that causes the tides will always be there
- **Hydroelectric energy:** Unless there is a drastic change in rain patterns, it will always be there

On the other hand, non-renewable resources such as fossil fuels are finite - our resources of them will run out eventually.

A second advantage is renewable resources are seen as being 'green', or environmentally friendly. This is because they do not emit carbon dioxide (the biggest contributor to global warming) into the atmosphere.

Non-renewable resources such as petroleum release CO_2 into the environment when they are combusted for energy. Other renewables such as biofuels are carbon neutral - producing them consumes about as much CO_2 as using them produces.

2. Disadvantages of renewable energy

Renewable energy is energy derived from sources that **will not run out.** Some of the present disadvantages are:

- **Solar** — panels are expensive. Governments are not all willing to buy home generated electricity. Not all climates are suitable for solar panels.
- **Wind** — turbines are expensive. Wind doesn't blow all the time, so they have to be part of a larger plan.
- **Waves** — different technologies are being tried around the world. Scientists are still waiting for the killer product.
- **Tides** — barrages (dams) across river mouths are expensive to build and disrupt shipping. Smaller turbines are cheaper and easier to install.
- **Rivers** — Dams are expensive to build and disrupt the environment. Smaller turbines are cheaper and easier to install.
- **Geothermal** — Difficult to drill two or three kilometers down into the earth.
- **Biofuel** — Often uses crop lands and crops (like corn) to produce the bio-alcohol. This means that more land has to be cleared to grow crops, or there is not enough food, or that food becomes more expensive

Q.6. What is sustainable development? Explain.

Ans. Sustainable development is an organizing principle for human life on a finite planet. It posits a desirable future state for human societies in which living conditions and resource-use meet human needs without undermining the sustainability of natural systems and the environment, so that future generations may also have their needs met.

Sustainable development ties together concern for the carrying capacity of natural systems with the social, political, and economic challenges faced by humanity. As early as the 1970s, 'sustainability' was

employed to describe an economy "in equilibrium with basic ecological support systems." Scientists in many fields have highlighted *The Limits to Growth*, and economists have presented alternatives, for example a 'steady state economy', to address concerns over the impacts of expanding human development on the planet.

Equitable Use of Resources for Sustainable Lifestyles: Scarcity of resources is the burning problem of modern technology. The twenty-first century will see growing human needs for resources since many parts of the world are using natural resources at a rate faster than the natural processes can replenish it.

Natural resources are limited. For example, the existing water sources are being subjected to heavy pollution. Global climatic changes are altering the quality of fresh water sources as a consequence of unknown effects on the hydrological cycle.

Sustainable development is currently being discussed as a focal theme in the field of development, planning and other associated aspects. In the light of self-defeating current mode of development and recurrent natural calamities, people are urged to ponder over the faults, shortcomings, lacunae, discrepancies and limitations of the ongoing developmental process and production system.

Q.7. What do you understand by Sustainable Energy?

Ans. Sustainable energy is the practice of using energy in a way that "meets the needs of the present without compromising the ability of future generations to meet their own needs."

When referring to methods of producing energy, the term "sustainable energy" is often used interchangeably with the term "renewable energy". In general, renewable energy sources such as solar energy, wind energy, geothermal energy, and tidal energy, are widely considered to be sustainable. However, particular renewable energy projects, such as the clearing of forests for production of biofuels, can lead to similar or even worse environmental damage when compared with using fossil fuel energy. There is considerable controversy over whether nuclear energy can be considered sustainable.

Sustainable energy sources can be used to generate electricity, to heat and cool buildings, and to power transportation systems and machines. Costs of sustainable energy sources have decreased immensely throughout the years, and continue to fall. Increasingly, effective government policies support investor confidence and these markets are expanding.

Sustainable energy strategies generally involve both the use of sustainable energy sources, and improvements in energy conservation. The organizing principle for sustainability is sustainable development, which includes the four interconnected domains: ecology, economics, politics and culture. Sustainability science is the study of sustainable development and environmental science.

Q.8.Give a brief account of Non fuel minerals resources in India.

Ans. Mineral resources are broadly classified into two categories, fuel and non-fuel. Fuel minerals include fossil fuels such as oil, natural gas, and coal, while non-fuel minerals are commonly understoo to include a variety of materials such as metals, metal alloys, and non metals. While fuel minerals, particularly oil and coal, have beenstudies, discussed, and debated upon extensively, and their security remains a dominan theme in policy and media, non-fuel mineals, despite bein induspensabl constituents of society, have been relatively understudied in India.

Advances in renewable energy technologies, telecommunications, automotive, and defense industries have all been made possible by incorporating new applications of non-fuel minerals such as silicon, indium, tungsten, titanium, tantalum, gallium, cadmium, selenium, tellurium, and earths.

Table 2: Main applications for select critical non-fuel minerals

Chromium	Stainless steels; manufacture of corrosion and abrasion resistant bricks; foundry; manufacture of chemicals used in a wide variety of end products like clothing, furniture, and so on.
Molybdenum	Missile and aircraft parts, valuable catalyst in petroleum refining, filament material in electrical applications, alloying agent for ultra-high strength steels, vital for development of nuclear power and water desalination plants, emerging uses in new mining technology and nano technology.
Tungsten	Light bulb filaments, television tubes, X-ray tubes (as both the filament and target), super alloys, and hard metals for cutting tool and drills used in metal-working and mining industries.
Rare earths	Automobiles, including hybrid vehicles, air conditioners, wind power generators, fluorescent lights, plasma screens, portable computers, handheld electronic devices.
Cobalt	Metallurgical applications, special alloys/supper alloys industry, aircraft and turbines, magnets, cutting tools, bonded tools for diamond industry, catalysts, dyes, pigments, pain driers/adhesives, glass, and ceramic.

Q.9. Why is Energy called the Oxygen of economy?

Ans. The world has been reeling from the financial crisis with reverberations being felt throughout the real economy on production, consumption, jobs and well-being. At times like these, we are all reminded of just how intertwined our future prospects have become and forced to reflect on how history has led us to our current circumstances.

Global energy demand and prices have been resilient during the recession, leading policy-makers in countries with the potential to produce energy to look to that sector as a potential engine for economic growth.

The energy sector constitutes a relatively modest share of GDP in most countries, except for those in which oil and gas income loom large. However, the energy sector's impact on the economy is greater than the sum of its parts. Most importantly, energy is an input to nearly every good and service in the economy. For this reason, stable and reasonable energy prices are beneficial to reigniting, sustaining and expanding economic growth.

Its broad supplier networks and resultant multiplier effect also drive the energy sector's influence on economic growth. The industry's well-paid, skilled workforce and high capital spending flow through the economy, creating jobs and spurring growth in seemingly unrelated sectors.

At the same time, the ability of a country to capitalize on supplier networks and the multiplier effect depends on the capacities of the local labour and industrial markets. Many resource-rich countries strive to maximize the economic benefits of their resource endowments by encouraging the growth of related industries.

For all of these reasons, the energy sector can make an important contribution to the recovery from the global downturn. For example, the oil and gas industry in the United States is an important bright

spot in an economy still struggling to find its footing. The US oil and gas extraction sector grew at a rate of 4.5% in 2011, compared to the overall GDP growth rate of 1.7%.

Q.10. Describe the role of energy sector in job creation.

Ans. The energy industry contributes to economic growth in two ways. First, energy is an important sector of the economy that creates jobs and value by extracting, transforming and distributing energy goods and services throughout the economy. As an example, in 2009 the energy industry accounted for about 4% of GDP in the United States. In some countries that are heavily dependent on energy exports the share is even higher: 30% in Nigeria, 35% in Venezuela and 57% in Kuwait.1 The energy industry extends its reach into economies as an investor, employer and purchaser of goods and services.

Second, energy underpins the rest of the economy. Energy is an input for nearly all goods and services. In many countries, the flow of energy is usually taken for granted. But price shocks and supply interruptions can shake whole economies. For countries that face chronic electricity shortages like India, continuing disruptions take a heavy, ongoing toll.

The Energy Industry's Direct Role in the Economy: The industry directly affects the economy by using labour and capital to produce energy. This role is particularly important when economic growth and job creation are such high priorities around the world. Figure 1 shows the energy sector's share of business sector GDP along with other industries in several Organisation for Economic Co-operation and Development (OECD) countries. Such data is difficult to obtain for other parts of the world.

The energy industry's large investment requirements make it very sensitive to the cost of capital. Competition from governments and businesses (including the energy industry) creates scarcity and drives up the cost of capital. However, capital costs are currently extremely low because of the depressed state of the global financial system. Now is a good time to consider investment in capital-intensive industries.

Q.11. Explain the role of energy prices in the economy.

Ans. In addition to the energy sector's economic contributions in general, relatively lower and stable energy prices help stimulate the economy. First, lower energy prices reduce expenses for consumers and businesses, increasing disposable income that can be spent in other ways. Second, lower energy prices reduce input costs for nearly all goods and services in the economy, thus making them more affordable.

The converse is also true: relatively higher energy prices place a drag on economic growth everywhere except in economies that are dominated by energy production. Global oil prices entered a long upward swing in 2004, and the trend accelerated sharply in 2007. This price rise contributed to the deep recession in the developed world that began in late 2007. Rising energy prices took purchasing power away from consumers, particularly from lower-income groups. They also brought about "a deterioration in consumer sentiment and an overall slowdown in consumer spending," according to James Hamilton, Professor of Economics at the University of California at San Diego.

Q.12. Compare Job creation VS Cost of energy.

Ans. Although the energy industry can be an engine of growth, energy choices affect prices. This fact is crucial to the overall economic impact of the industry. Investments might create a lot of jobs and direct economic benefits, but if they also raise energy prices, the net effect could be negative. However, consumer price subsidies or price caps can also harm the economy. Subsidies can be very expensive

for governments and price caps can reduce incentives to invest in energy capacity. In either case, the eventual removal of the subsidy or price cap can also cause substantial economic disruption.

The economic and employment impacts of growing sources of energy differ across the industry. In the case of oil and gas, unconventional wells cost two to four times as much as their conventional counterparts. Despite these high upfront costs, the full cycle costs of production from unconventional sources in the United States tend to be less than their conventional counterparts. For example, in 2011 the unit costs of producing shale gas were 40% to 50% below conventional gas. Unconventional wells are generally more productive than conventional wells - initial production from shale gas wells is generally three times that of conventional wells. Marked increases in productivity and decreases in unit costs explain why the growing oil and gas sector in the United States has been so positive for industry job creation and overall economic growth.

The picture in electricity generation is more mixed. According to our analysis, wind and solar PV generate more jobs per unit of energy delivered than natural gas in construction phase. However, generating more jobs per MW may not be the most efficient use of investment dollars. For instance, although solar PV installation creates a large number of job-years per unit of capacity, the cost of these jobs is reflected in the higher cost of producing electricity.

Q.13. Discuss about energy policy of India.

OR

Q.13. Discuss in detail about energy consumption in India.

Ans. The energy policy of India is largely defined by the country's expanding energy deficit and increased focus on developing alternative sources of energy, particularly nuclear, solar and wind energy. India ranks 81 position in overall energy self-sufficiency at 66% in 2014.

The primary energy consumption in India grew by 7.9% in 2018 and is the third biggest after China and USA with 5.8% global share. The total primary energy consumption from crude oil (239.1 Mtoe; 29.55%), natural gas (49.9 Mtoe; 6.17%), coal (452.2 Mtoe; 55.88%), nuclear energy (8.8 Mtoe; 1.09%), hydro electricity (31.6 Mtoe; 3.91%) and renewable power (27.5 Mtoe; 3.40%) is 809.2 Mtoe (excluding traditional biomass use) in the calendar year 2018. In 2018, India's net imports are nearly 205.3 million tons of crude oil and its products, 26.3 Mtoe of LNG and 141.7 Mtoe coal totaling to 373.3 Mtoe of primary energy which is equal to 46.13% of total primary energy consumption. India is largely dependent on fossil fuel imports to meet its energy demands - by 2030, India's dependence on energy imports is expected to exceed 53% of the country's total energy consumption. About 80% of India's electricity generation is from fossil fuels. India is surplus in electricity generation and also marginal exporter of electricity in 2017. Since the end of calendar year 2015, huge power generation capacity has been idling for want of electricity demand. India ranks second after China in renewables production with 208.7 Mtoe in 2016.

In 2017-18, the per-capita energy consumption is 23.355 Giga Joules (0.558 Mtoe) excluding traditional biomass use and the energy intensity of the Indian economy is 0.2332 Mega Joules per INR (56 kcal/INR). Due to rapid economic expansion, India has one of the world's fastest growing energy markets and is expected to be the second-largest contributor to the increase in global energy demand by 2035, accounting for 18% of the rise in global energy consumption. Given India's growing energy demands and limited domestic oil and gas reserves, the country has ambitious plans to expand its renewable and most worked out nuclear power programme. India has the world's fourth largest wind power market and also plans to add about 100,000 MW of solar power capacity by 2020.

Q.14. What is the situation with Electricity generation in India?

Ans. The installed capacity of utility power plants is 314.64 GW as on 31 January 2017 and the gross electricity generated by utilities during the year 2015-16 is 1168.359 billion kWh which includes auxiliary power consumption of power generating stations. The installed capacity of captive power plants in industries (1 MW and above) is 50,289 MW as on 31 March 2017 and generated 197 billion kWh in the financial year 2016-17. In addition, there are nearly 75,000 MW aggregate capacity diesel generator sets with units sizes between 100 KVA and 1000 KVA. All India per capita consumption of Electricity is nearly 1,122 kWh during the financial year 2016-17.

Total installed Power generation Capacity (end of April 2017)

Source	Utilities Capacity (MW)	%	Captive Power Capacity (MW)	%
Coal	194,402.88	59.9	29,888.00	59.43
Hydroelectricity	44,594.42	14.0	64.00	0.11
Renewable energy source	50,018.00	15.9	Included in Oil	-
Natural Gas	25,329.38	8.1	6,061.00	12.05
Nuclear	6,780.00	1.8	-	-
Oil	837.63	0.3	14,285.00	28.41
Total	**329,204.53**		**50,289.00**	100

Q.15. Describe in brief about the energy conservation Act of 2001.

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

Q.16. Throw some light on rural electrification in India with respect to its current situation.

Ans. As on 28 April 2018, all Indian villages were electrified. India has achieved 100% electrification of all rural and urban households. As of 4 January 2019, 211.88 million rural households are provided with electricity, which is nearly 100% of the 212.65 million total rural households. Up to 4 January 2019, 42.937 million urban households are provided with electricity, which is almost 100% of the 42.941 million total urban households. 89% of house holds in the country use LPG drastically reducing the use of traditional fuels - fuelwood, agricultural waste and biomass cakes - for cooking and general heating needs.

Q.17. What do you know about renewable energies? Does India consume any of its renewable energy?

Ans. Renewable energies include wind, solar, biomass and geothermal energy sources. This means all energy sources that renew themselves within a short time or are permanently available. Energy from hydropower is only partly a renewable energy. This is certainly the case with river or tidal power plants. Otherwise, numerous dams or reservoirs also produce mixed forms, e.g. by pumping water into their reservoirs at night and recovering energy from them during the day when there is an increased demand for electricity. Since it is not possible to clearly determine the amount of generated energy, all energies from hydropower are displayed separately.

In 2015, renewable energies accounted for around 36.0 percent of actual total consumption in India.

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