Learning Objective of the Class:

Introduction to different forms of energy and utilization and factors affecting of different fuels, and Key Energy trends in India and Planning and Implementation of Renewable sources

Module 1

Introduction to Energy

Syllabus Overview:

Basic Introduction to Energy

- Energy and power forms of energy
- primary energy sources
- energy flows
- world energy production and consumption
- Key energy trends in India:
  - Demand
  - Electricity
  - Access to modern energy
  - Energy production and trade
- Factors affecting India's energy development:
  - Economy and demographics
  - Policy and institutional framework
  - Energy prices and affordability
  - Social and environmental aspects
  - Investment

Basic introduction to energy

Any physical activity in this world, whether carried out by human beings or by nature is caused due to flow of energy in one form or other. The word 'energy' itself is derived from the Greek word 'en-ergon' which means 'in-work' or 'work content'. The work output depends on the energy input.

Energy is one of the major inputs for the economic development of any country. In the case of developing countries, the energy sector assumes a critical importance in view of the ever increasing energy needs requiring huge investments to meet them.

ENERGY

Stated as simply as possible, energy is the capacity to do work. ***Energy is what makes it possible to push things around***. The "thing" might be a car moving down a highway, a lump of bread dough on your kneading board, or an electron in the filament of a light bulb. Pushing these things around is work, and it takes energy to do it. If we know the strength of the force we need in order to move an object, and the distance we're going to move it, we can calculate the amount of energy we'll need.

POWER

Energy measures the total quantity of work done; it doesn't say how fast you can get the work done. Power is defined as the rate of producing or consuming energy.

Relationship between Energy and Power

Energy is the ability (or capacity) to do **work**. When utilising an energy conversion we are usually concerned with two things: the quantities of energy involved and the rate at which energy is converted from one form to another, or (particularly in the case of electricity) transmitted from one place to another via a **medium**, such as water or high-voltage cable. The rate per second at which energy is converted or transmitted is called the **power**. Thus there is a mathematical relation between the two concepts:

Energy = power x time

ENERGY V/S POWER

	Energy	Power
Definition	Energy is the capacity to do work. Energy is power integrated over time.	Power is the rate at which work is done, or energy is transmitted.
Unit	joule	watt = joule/second
Common symbol(s)	J	P
Example	I left a 60W light bulb on for 30 days, which raised my electric bill by 43.2 kWh (kilowatt-hours).	My car's battery can provide 500 amps at 12 volts, which equals 6 kW of power.
	Energy can be transformed from one form to another	Power is transmitted/generated

Primary energy sources

- **Biomass energy**: any material of plant or animal origin such as woody biomass (stems, branches, twigs) non-woody biomass (stalks, leaves, grass), agricultural residues (rice husk, coconut shell), and animal and human faeces. The energy can be converted through a variety of processes to produce a solid, liquid or gaseous fuel. The biomass usually needs some form of processing stage prior to conversion, such as chopping, mixing, drying or densifying. Solar energy: energy from the sun comes as either direct radiation or diffuse radiation. Direct radiation is only collected when the collector (e.g. a leaf or a solar panel) faces the sun. Diffuse radiation comes from all directions and is even present on a cloudy day. The energy falling on a surface of a specified area is less for diffuse radiation than direct radiation. Solar energy can be converted through thermal solar devices to heat, or through photovoltaic cells to electricity.
- **Hydro energy:** utilises the potential energy from water stored behind dams, weirs or natural heads (water falls) and the kinetic energy of streams or rivers. Water wheels and hydro turbines are used to convert this energy source to mechanical or electrical energy
- **Wind energy:** the kinetic energy from the wind is converted by wind turbines (also known as wind generators or windmills) into mechanical energy (usually for water pumping) or electrical energy.
- **Geothermal energy:** heat flow from the earth's core to the surface by molten rock or hot water. The heat can be used for space heating, drying, process heat applications or electricity generation
- **Animate energy:** energy delivered by humans and animals. This is a major source of energy in agriculture in many developing countries, but never appears in national energy balances
- **Ocean energy:** includes three energy sources: wave and tidal, which both utilise the kinetic energy of moving water, and ocean thermal, which utilises the heat flow between the warm surface waters and cool deep waters of tropical oceans. All three are still at early stages of development, but the intention is to use them to generate electricity
- **Fossil fuels**: Coal, crude oil and natural gas. The main commercial fuels around the world
- **Nuclear energy:** energy released when the nuclei of atoms (usually uranium) break apart. This energy is utilised by converting it into electrical energy. Although these sources are called primary, with the exceptions of solar, nuclear and tidal, they are not ultimate sources of energy. The remainder are come, either directly or indirectly, from solar energy

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Learning outcome: Able to learn the defination of energy & power and primary sources of environment

Assignment question:

1. Define Energy and Power and Explain the relationship between energy and power and Differentiate the same
2. Explain different primary sources available in environment

FORMS OF ENERGY

The numerous existing energy sources can be classified in different ways:

1. Primary sources
2. 2. Secondary sources

Primary Sources: Can be used directly, as they appear in the natural environment:
Ex: Coal, Oil, Natural Gas And Wood, Nuclear Fuels (Uranium), The Sun, The Wind, Tides, Mountain Lakes, The Rivers (From Which Hydroelectric Energy Can Be Obtained) And The Earth Heat That Supplies Geothermal Energy.

Secondary Sources: Derived from the transformation of primary energy sources
Ex: petrol, that derives from the treatment of crude oil ,Electric energy, obtained from the conversion of mechanical energy (power plants)

Other forms as mentioned below:

Kinetic energy: energy possessed by a moving object, such as wind or water in a stream. Speed and mass of the object influence the amount of kinetic energy. The faster the wind blows or the more water flowing in a stream the more energy is available.

Potential energy: energy possessed by an object's position relative to the earth's surface. This is stored energy which if the object falls is converted into kinetic energy. For example, water behind a dam: the higher the dam or the greater the amount of water, the higher the potential energy.

Thermal energy (heat): A form of kinetic energy due to the random motion of the atoms or molecules (the building blocks) of solids, gases or liquids. The faster the atoms or molecules the greater the thermal energy of the object, usually described as the hotter the object is.

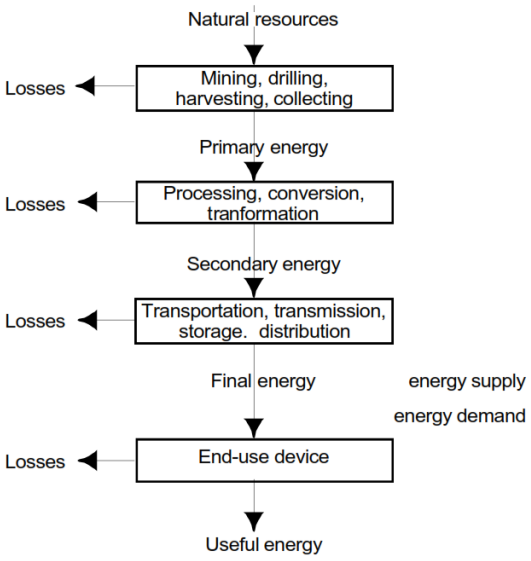
Chemical energy: A form of energy stored in atoms or molecules. This energy is usuallyutilised by converting into heat (combustion) or electrical energy (batteries).

Electrical energy: Most familiar in the form of electricity, which is the organised flow of electrons (one of the building blocks of an atom) in a material, usually a metal wire.

Electromagnetic energy (radiation) which all objects, in different amounts, emit or radiate. The most familiar forms are light and sound.

Mechanical energy: The energy of rotation usually associated with a rotating shaft.

Energy Flows:



It was remarked earlier that energy conversions from the original source to the useful form often take place in a number of intermediate stages. The energy flows from one form to another at each conversion, transformation or transport step, and these steps can be considered as a chain. Constructing such a chain enables an energy analyst to look at the efficiencies of the different stages in order to reduce costs and avoid unnecessary losses..

When constructing the chain, energy is classified into four types: primary, secondary, final and useful. **Primary energy** is the energy in the form in which it is available in the natural environment.

Secondary energy is the energy ready for transport or transmission. **Final energy** is the energy which the consumer buys or receives and **useful energy** is the energy actually required to perform the work. To illustrate the difference between final and useful energy, consider a light bulb: the final energy of the process enters the bulb, but most is wasted as heat. The useful energy, the light, may represent less than 10% of the final energy. This example aside, useful energy is almost always in the form of heat or mechanical **shaft energy**. For or a few end uses, for example, communications equipment, electricity is the useful form.

An example of an energy flow or chain is the use of water to run a saw mill. The primary energy is potential energy stored in the water in a dam. The water is used in a hydro power station, where the potential energy is converted to electricity – the secondary energy. The electricity is transmitted to the saw mill, where it is converted to the useful form of shaft energy. In this case, the secondary and final forms are the same.

Learning outcome: Able to learn the different form of energy and Energy flow

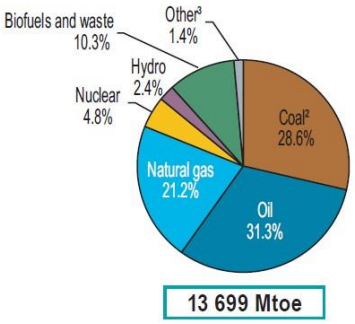
Assignment question:

1. Define Energy Flow diagram briefly w.r.t Energy
2. Explain different forms of Energy Present in Environment

WORLD ENERGY SCENARIO:

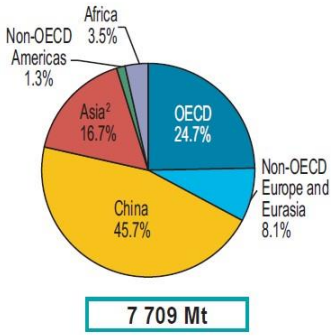
Energy demand in all over the world is increasing day by day. Major growth in energy demand is projected in developing countries. Coal, Oil & gas are the three major primary sources of energy. World coal reserves are likely to last over 200 years. Both oil & gas reserves likely to last 45-65 years.

Production:



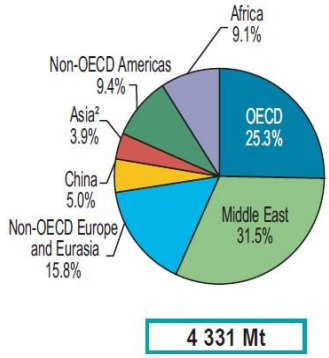
The global energy production at the end of 2014 was equivalent to 14000 Million Tonnes of Oil Equivalent (MToE). Coal Accounted for 29% , Oil 31 %, Natural gas for 21% and other at 18% (including nuclear, hydro, biofuels etc)

1. Coal



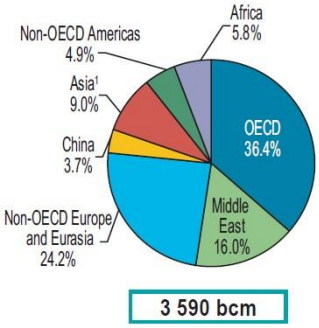
Global coal production stood at 7700 MToE as on 2015.Global coal production fell by 4% when compared to historical data. China accounted for a larger share with about 46%, other Asian countries about 17%, OECD (Organisation for Economic Co-operation and Development) countries about25%.

2. Oil



Global oil production stood at 4300 MToE as on 2015. Global oil production increased rapidly (3.2%). Middle east accounted for about 32%, Europe and Asia about 16%, America about 9% compared to historical data.

3. Natural Gas

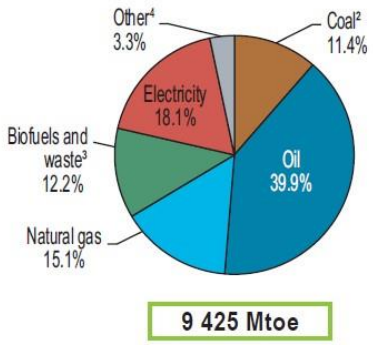


Global natural gas production stood at 4000 billion cubic meter (bcm) as on 2015.Global production grew by 2.2% compared to historical data. OECD countries accounted for 37 % share while Europe and Eurasia 24 %, Asia about 9%.

Consumption

The developed countries attributed to high energy consumption as compared to developing countries.80% of world population lies in developing countries. Their energy consumption amount is only 40% of the world's total energy consumption. Industrialized countries /people use 4-5 times more than world average energy consumption & 9 times more than the average of the developing countries. **Primary energy consumption** is projected to grow at an average **annual rate of 2.7%** between 2011-2020.

Global energy consumption was 9425 MToE as on 2014.Oil accounted for 40%, Electricity about 18%, natural gas about 15%, Coal about 11%.



Coal: Global coal consumption fell by 1.8% compared historically. This was accounted by US by a decline of 12.7%, China of 1.5%. India recorded an increase in coal dependence by about 5%.

Oil: Global Oil consumption grew by 1.9 million barrels/day (nearly 1.9%) as compared to historical data. US accounted for increase in 1.6%, China about 6.5%, India about 8.1% with an exception of Japan which recorded a decline of about 4%.

Natural Gas: Global natural gas consumption grew by nearly 1.7%. Iran accounted for 6.2%, China about 4.7%, US about 3%. Meanwhile, few countries recorded largest volumetric decline including Russia (5%) and Ukraine (21%).

Conclusion

Developed countries are consuming more energy with energy demand continues to grow strongly. Renewable sources will dominate and energy system complexity will increase by 2050. Energy efficiency is crucial in dealing with demand outstripping supply. Investments need to be large with focus on requirement of strong environmental policies

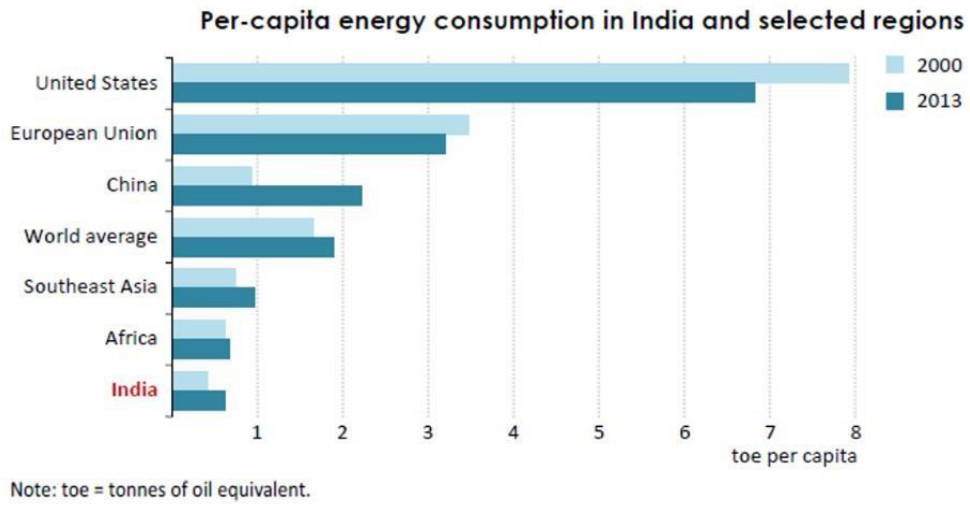
KEY ENERGY TRENDS IN INDIA:

The various key energy trends in India include

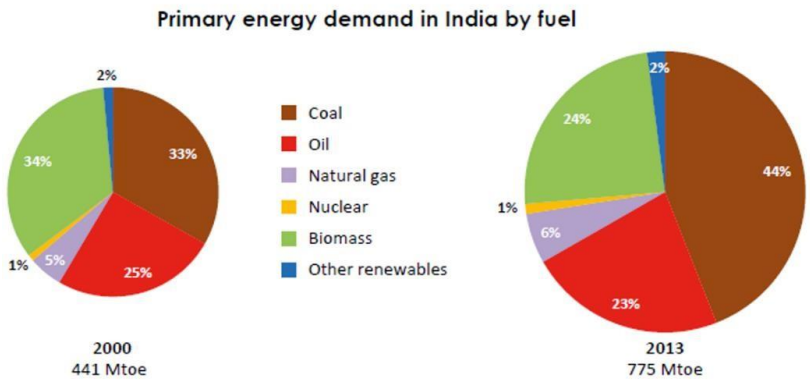
- Demand
- Electricity
- Access to Modern Energy
- Energy Production and Trade

1.Demand

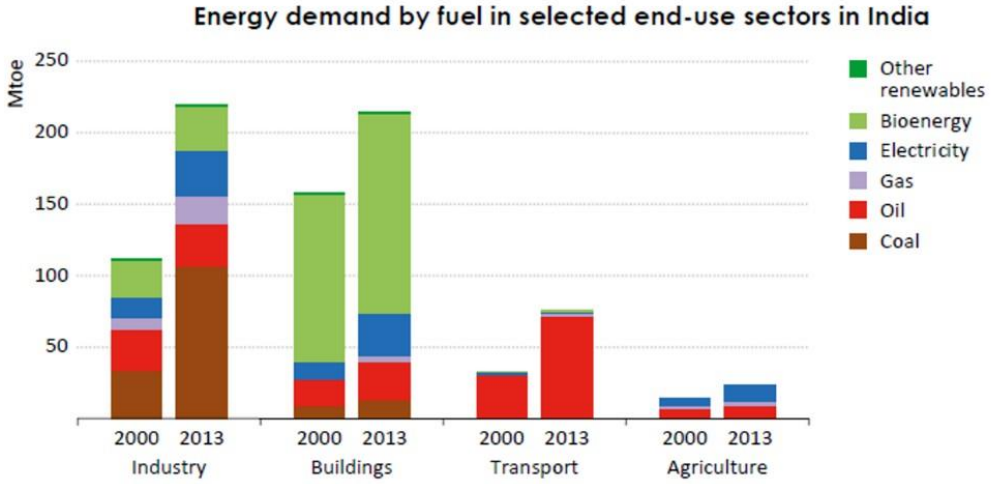
India has been responsible for almost 10% of the increase in global energy demand since 2000. Its energy demand in this period has almost doubled, pushing the country's share in global demand up to 5.7% in 2013 from 4.4% at the beginning of the century. Expressed on a per-capita basis, energy demand in India has grown by a more modest 46% since 2000 and remains only around one-third of the world average as shown below.



Almost three-quarters of Indian energy demand is met by fossil fuels, a share that has increased since 2000 because of a rapid rise in coal consumption. Coal now accounts for 44% of the primary energy mix. The availability and affordability of coal relative to other fossil fuels has contributed to its rise, especially in the power sector.



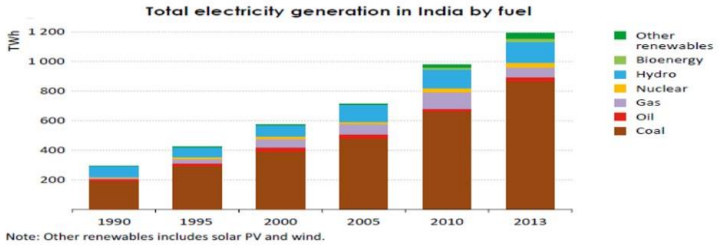
Oil consumption in 2014 stood at 3.8 million barrels per day (mb/d), 40% of which is used in the transportation sector. Natural gas makes up a relatively small share of the energy mix (6% in 2013 compared with 21% globally). Hydropower, nuclear and modern renewables (solar, wind and geothermal) are used predominantly in the power sector but play a relatively small role in the total energy mix.

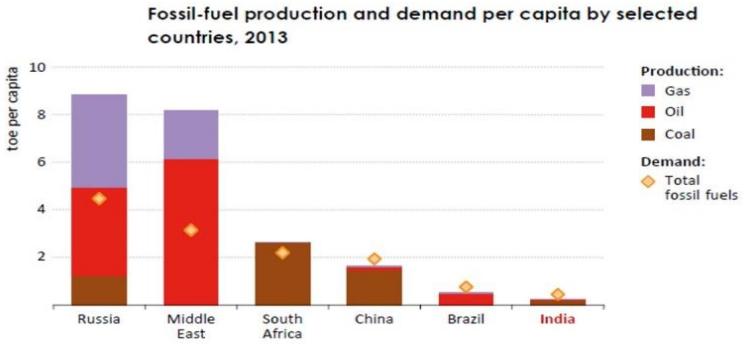


Energy demand had traditionally been dominated by the buildings sector (which includes residential and services). In the buildings sector, a key driver of consumption in both rural and urban areas has been raising levels of use of appliances. As a result, electricity demand in the buildings sector grew at an average rate of 8% per year over 2000-2013 as shown.

2. Electricity

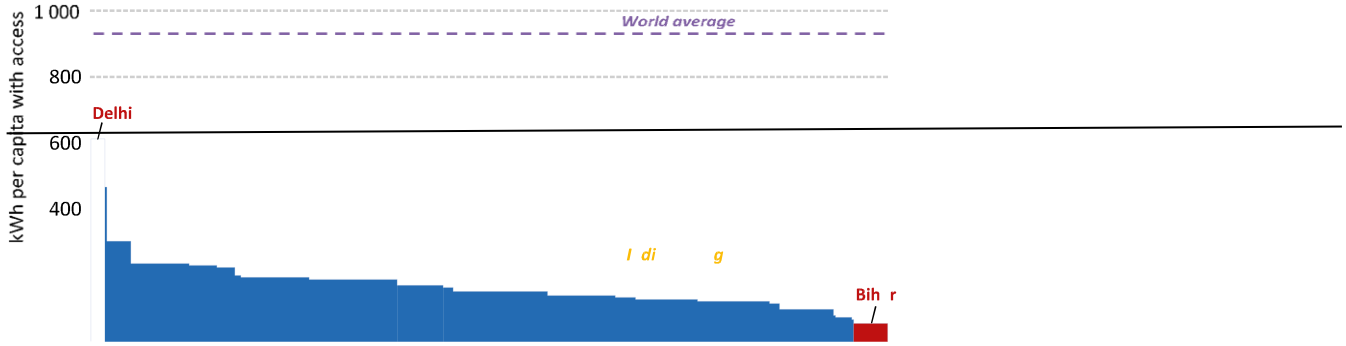
The country's electricity demand in 2013 was 897 terawatt-hours (TWh), up from 376 TWh in 2000, having risen over this period at an average annual rate of 6.9%. Electricity now constitutes some 15% of final energy consumption since 2000. The situation varies from state to state, but higher tariffs paid by commercial and industrial consumers are typically not enough to offset the losses arising from subsidies to residential and agricultural consumers, despite efforts to raise retail rates in recent years





On the supply side, India has some 290 gigawatt (GW) of power generation capacity, of which coal (60%) makes up by far the largest share, followed by hydropower (15%) and natural gas (8%). The mix has become gradually more diverse: since 2000, almost 40% of the change in installed capacity was non- coal. This is reflected also in the figures for generation, which show how renewable are playing an increasingly important role.

Annual residential electricity consumption per capita by state in India (for those with access), 2013



Note: Annual residential electricity consumption per capita (for those with access) by state is estimated by dividing the annual residential electricity consumption by the number of people with electricity access for each state. This estimate is not comparable with the common "electricity consumption per capita" indicator, which takes into account electricity consumption of all sectors divided by total population.

3. Access to Modern Energy

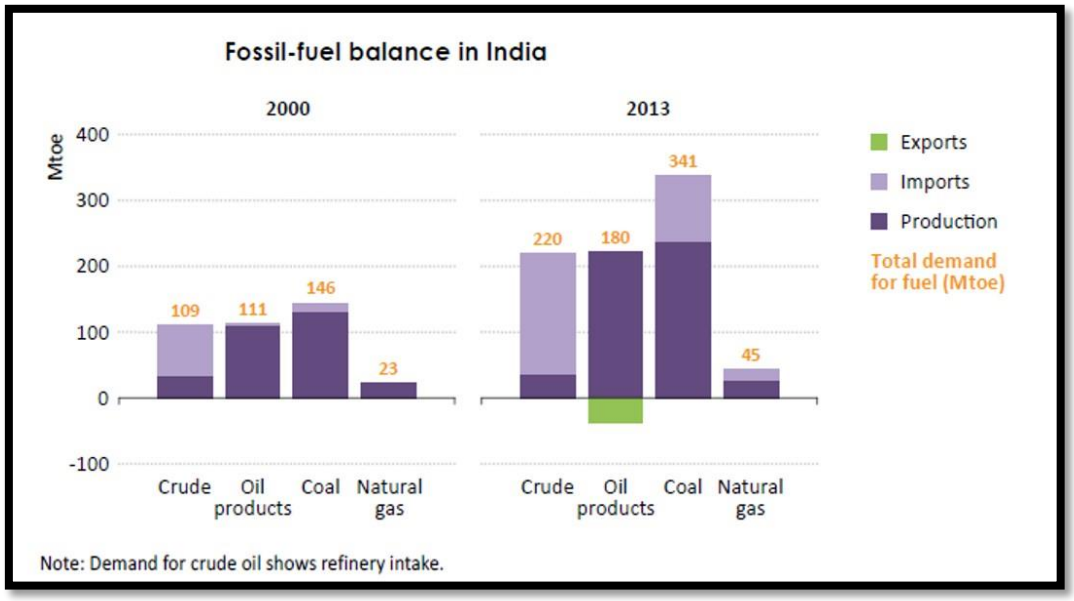
India has made great strides in improving access to modern energy in recent years. Since 2000, India has more than halved the number of people without access to electricity and doubled rural electrification rates. Nonetheless, around 240 million people, or 20**% of the population, remain without access to electricity**. The **electrification rates are already well above 90%.** Of the total without access, the large majority live in rural areas where extending access is a greater technical and economic challenge. In urban areas, electrification rates are much higher, but the quality of service remains very uneven.

India's rural electrification programme, **the Rajiv Gandhi Grameen Vidyutikaran Yojana (RGGVY), was launched in 2005 and aimed to provide electricity to villages of 100 inhabitants or more and free electricity to people below the poverty line.** The effective implementation of RGGVY has faced several challenges and there are strong variations in outcomes between states.

In July 2015, RGGVY was subsumed within a new scheme, **the Deen Dayal Upadhyaya Gram Jyoti Yojana (DDUGJY). The main components of this scheme are the separation of distribution networks between agricultural and non-agricultural consumers to reduce load shedding, strengthening local transmission and distribution infrastructure, and metering.**

Aside from those without electricity, India also has the largest population in the world relying on the traditional use of solid biomass for cooking. The government has made a major effort to address its pollution issues, primarily through the subsidised availability of LPG as an alternative cooking fuel.

4. Energy Production and Trade



1. Coal

India has the third-largest hard coal reserves in the world (roughly 12% of the world total), as well as significant deposits of lignite. Yet the deposits are generally of low quality and India faces major obstacles to the development of its coal resources. **In 2013, India produced almost 340 million tonnes of coal equivalent (Mtce), but it also imported some 140 Mtce**.

Around 7% of national production comes from captive mining, i.e. large coal- consuming companies that mine for their own use. At present, more than 90% of coal in India is produced by open cast mining.

2. Oil and Oil Products

India is one of the few countries in the world that rely on imports of crude oil while also being significant net exporters of refined products. India has relatively modest oil resources and **most of the proven reserves (around 5.7 billion barrels) are located** in the western part of the country, notably in **Rajasthan and in offshore areas near Gujarat and Maharashtra**. Most of the remaining production comes from joint ventures with the national oil and gas companies and from blocks awarded under successive licensing. India has almost doubled its refining capacity in the last ten years and has added more than 2 mb/d of new capacity since 2005, with strong private sector participation. With refinery output exceeding total demand by roughly 1 mb/d, India is a net exporter of all refined products except LPG.

3. Natural Gas

Natural gas has a relatively small share (6%) of the domestic energy mix. Production of conventional gas reached 34 bcm in 2013 & was supplemented by LNG imports. The majority state-owned gas company, GAIL, is the largest player in the midstream and downstream gas market.

Learning outcome: Able to learn the different energy scenarios of different fuels and important key energy trends in India

Assignment question:

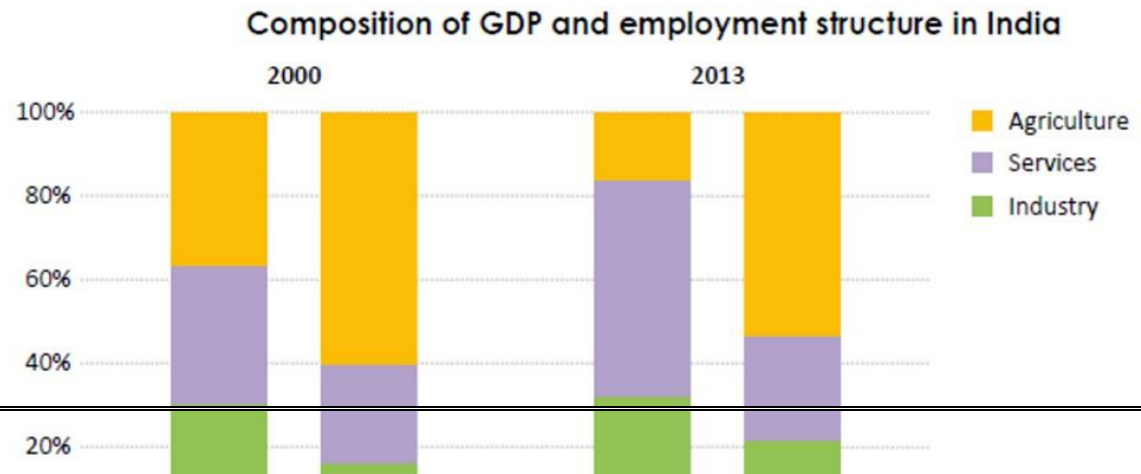
1. Interpret World Energy Scenario with respect to production & consumption using relevant statistics
2. Explain the various key energy trends in India
3. With relevant statistics, Enumerate the primary energy production trend for our country India

FACTORS AFFECTING INDIA'S ENERGY DEVELOPMENT

The various factors that affect our country's energy development are

1. Energy and Demographics
2. Policy and Institutional Framework
3. Energy Process and affordability
4. Social and environmental aspects
5. Investment

1. Energy and Demographic



India's economy has grown at an **average rate of 6.5%** a year, second only to China among the large emerging economies, and **two-and-a-half-times the global average.** India alone has accounted for over **9% of the increase in global economic output since 1990**. Despite this progress, income per capita is still low and a gap has emerged between India and its counterparts Services sector has been the major driver of growth in India's economy, accounting **for around 60% of the increase in GDP** between 1990 and 2013. The services sector employs only around one-quarter of the labour force. The agricultural sector, with less than 20% of GDP (compared with just over 35% in 1990), continues to account for around half of total employment as shown in above figure

The government has expressed its intention to re-balance the economy and announced the **"Make in India" initiative**, with an intention of increasing the share of manufacturing in GDP to 25% by 2022 and creating 100 million jobs in the process**.**

2. Policy and Institutional Framework

The direction that national and state policies take, and the rigour and effectiveness with which they are implemented, will naturally play a critical role in India's energy outlook and has few policies listed such as **Integrated Energy Policy 2008, National Action Plan on Climate Change** ,Planning, Commission (now the National Institution for Transforming India, [**NITI Aayog])**

Some key aspects of the emerging energy vision are

- A commitment to the efficient use of all types of energy in order to meet rapidly growing demand
- **Increase the target for renewables to 175 GW by 2022**
- A sharpened focus on achieving universal access to modern energy, including the objective of supplying round-the-clock electricity to all of India's population
- Reorientation of energy subsidy programmes
- A drive for market-oriented solutions and **increased private investment (including foreign investment) in energy**, both through some energy-specific reforms
- Drive to simplify and deregulate the business environment.
- A pledge to pursue a more climate-friendly and cleaner path than the one followed thus far by others at corresponding levels of economic development.

- Twin energy-related commitments **to increase the share of non-fossil fuel power generation capacity to 40% by 2030** and **to reduce the emissions intensity of the economy by 33-35% by the same date, measured against a baseline of 2005.**

3. Energy Prices and Affordability

The relationship between income levels, energy prices and energy expenditure is fundamental to the evolution of India's energy system. Energy consumption increases with income. Level of consumption and the fuel choice are also affected by location. Household expenditure on energy is, on average, almost **two-and-a-half-times higher in urban centres than in rural areas.** India has made significant moves towards market-based pricing for energy in recent years. Gasoline (in 2010) and diesel (2014) prices have both been deregulated

Note: Subsidies to oil product consumption remain

Ex: LPG, the government is committed to make them more efficient through the use of "AADHAAR"

4. Social and environmental aspects

Pollution:- India is burning more fossil fuels, and biomass than it has at any other time in the past, releasing more pollutants, including fine particulate matter and sulphur and nitrogen oxides,into the air.

Deteriorating air quality in growing urban centres is becoming an alarming issue for India. Estimated that life **expectancy, as a result, is reduced by 3.2 years** for each person living in these areas

Land: - Welfare of India's rural population is closely linked to the amount of land they have available for productive use. Land acquisition for public or private enterprises wishing to build infrastructure, from roads and railways to power plants and steel mills, is therefore an issue Legislative changes introduced in 2013 introduced stringent procedural requirements for land acquisition. Some of the measures include

- Defining compensation payments and
- Rehabilitation and resettlement benefits
- Need to secure the consent of 80% of affected families in the case of land acquisition (70% for acquisitions by public-private partnerships)

Water:-

High rates of population and economic growth, along with highly inefficient patterns of water use in the agricultural sector, are putting severe strain on India's water resources. **Around 90% of India's water withdrawal is for use in agriculture and livestock,** often extracted by tube wells powered from the grid and drawing from groundwater reserves. Subsidised electricity

tariffs for agricultural users and a lack of metering have led to hugely inefficient consumption of both electricity and water

5. Investment:

Since 2000, investment in energy supply in India has increased substantially, reaching **almost $77 billion on average since 2010** with power sector absorbing the largest share. India's government aims to **increase investment in infrastructure to 8.2% of GDP from roughly 7.2% in 2007- 2011**. 2014 saw a significant **increase in FDI inflows**, which rose by **22% compared to the previous year**

Learning outcome: Able to learn the different factors affecting the India Energy Development

Assignment question:

1. Outline the factors that affecting India's energy development (Note: All the above 5 factors explain in details)