RV College of Engineering®

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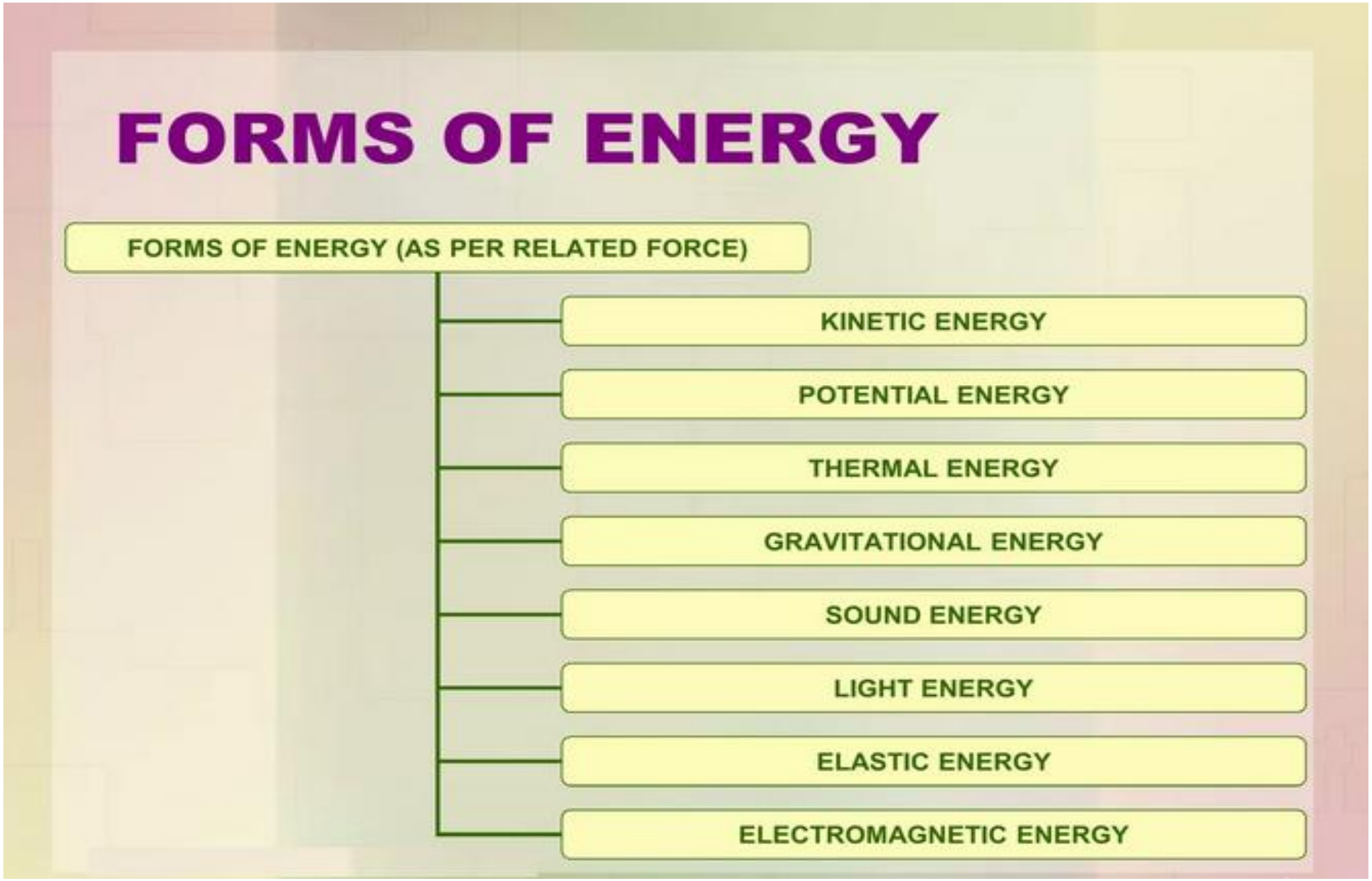
Renewable Energy Sources:
Emerging Technologies

Unit 1
Energy and Energy Resources

INTRODUCTION

- **Energy** : Ability to do work.
- Derived from Greek *energeia*, "activity, operation", from *energos*, "active, working".
- A **scalar physical quantity** that describes the amount of **work** that can be performed by a **force**.
- It is an attribute of objects and systems that is subject to **Law of Conservation of Energy**.

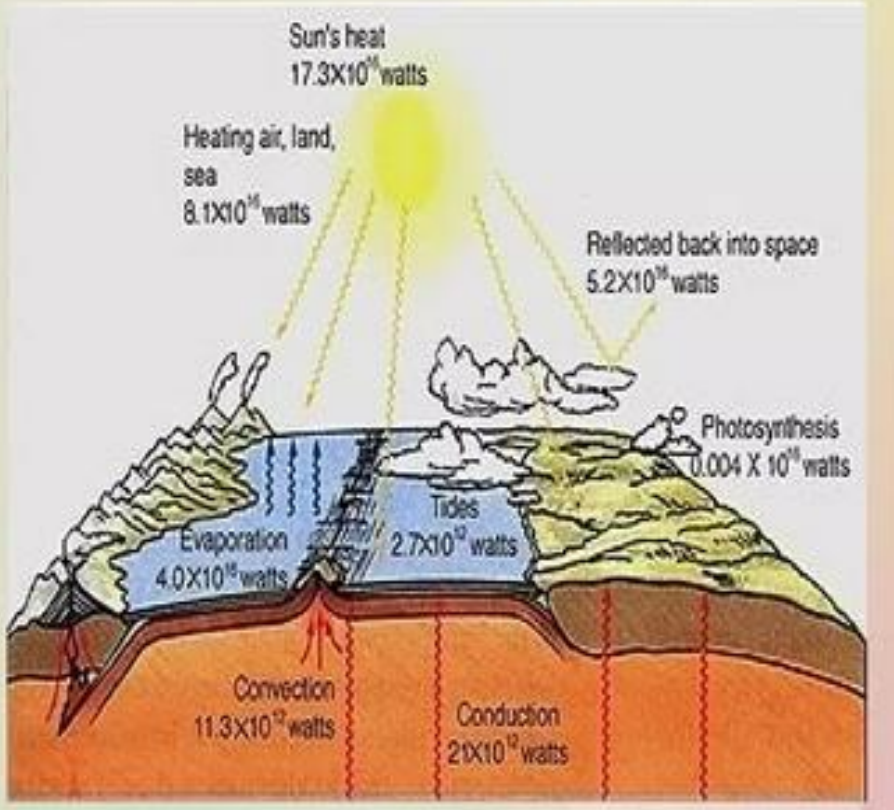
Forms of Energy



Primary Energy Sources

PRIMARY ENERGY SOURCES

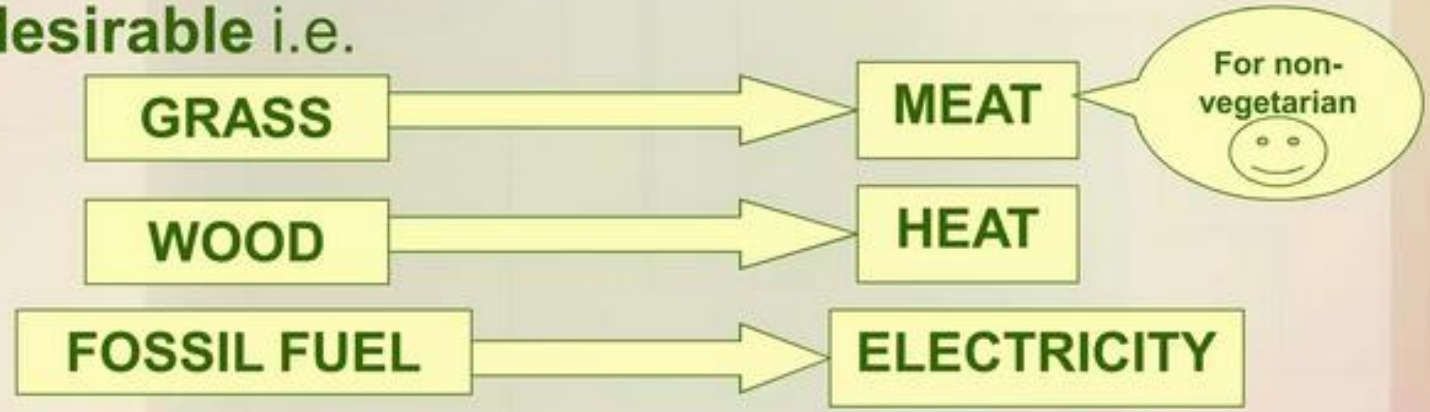
- Without Energy, Life can not exist.
- All forms of life extract energy from the environment and convert it to forms which can be used.
- Our environment has three primary energy sources :
  - **Solar energy**
    - radiant energy
    - **17.3×10^{16} watts**
  - **Energy the Earth's interior**
    - geothermal energy
    - **32.3×10^{12} watts**
  - **Planetary energy**
    - energy of gravitational attraction
    - energy of tides
    - **2.7×10^{12} watts**



Harvesting Energy

HARVESTING ENERGY

- Humans **convert energy** from forms that are **less desirable** to those that are **more desirable** i.e.



- Throughout history, man has **developed ways** to expand his ability to **harvest energy**.

Some Interesting Facts

SOME INTERESTING FACTS

- The **Primitive Man** found in East Africa **1,000,000 years ago**, who had **yet to discover fire**, had access only to the food he ate so his **daily energy consumption** has been estimated at **2kCal** or 2,000 dietary calories.
- Energy consumption of the **Hunting Man** found in Europe about **100,000 years ago** was about **2.5 times** that of the primitive man because he had **better methods of acquiring food** and also **burned wood** for both **heating and cooking**.

Some Interesting Facts

SOME INTERESTING FACTS (contd.)

- Energy consumption increased again by almost **2.5 times** as man evolved into the **Primitive Agricultural Man** of about **5,000 years ago** who **harnessed draft animals** to aid in growing crops.
- The **Advanced Agricultural Man** of **1400 A.D.** in North-Western Europe again **doubled** the amount of **energy consumption** as he began inventing devices to **tap the power of wind and water**, began to utilize small amounts of **coal for heating** and **harnessed animals to provide transportation**.

Some Interesting Facts

- The dawn of the age of **Industrialization**, ushered in by the invention of the **Steam Engine**, caused a **3-fold increase in energy consumption** by **1875**. Among other things, the steam engine allowed man to unlock Earth's vast **concentrated storage deposits** **coal, gas and oil** so he **no longer** was **limited to natural energy flows**.

Some Interesting Facts

SOME INTERESTING FACTS (contd.)

- **After Industrialization**, the **rate of Energy Consumption increased dramatically** over a period of just a few generations. The **Technological Man** of **1970** in the U.S. consumed approximately **230,000 Kcal** of energy **per day (~115 times that of primitive man)** with about **26%** of that amount being **electrical energy**. Of that electrical energy only about **10% resulted in useful work** while the remaining **16%** was **wasted** by **inefficiencies** in electrical **generation and transmission**.

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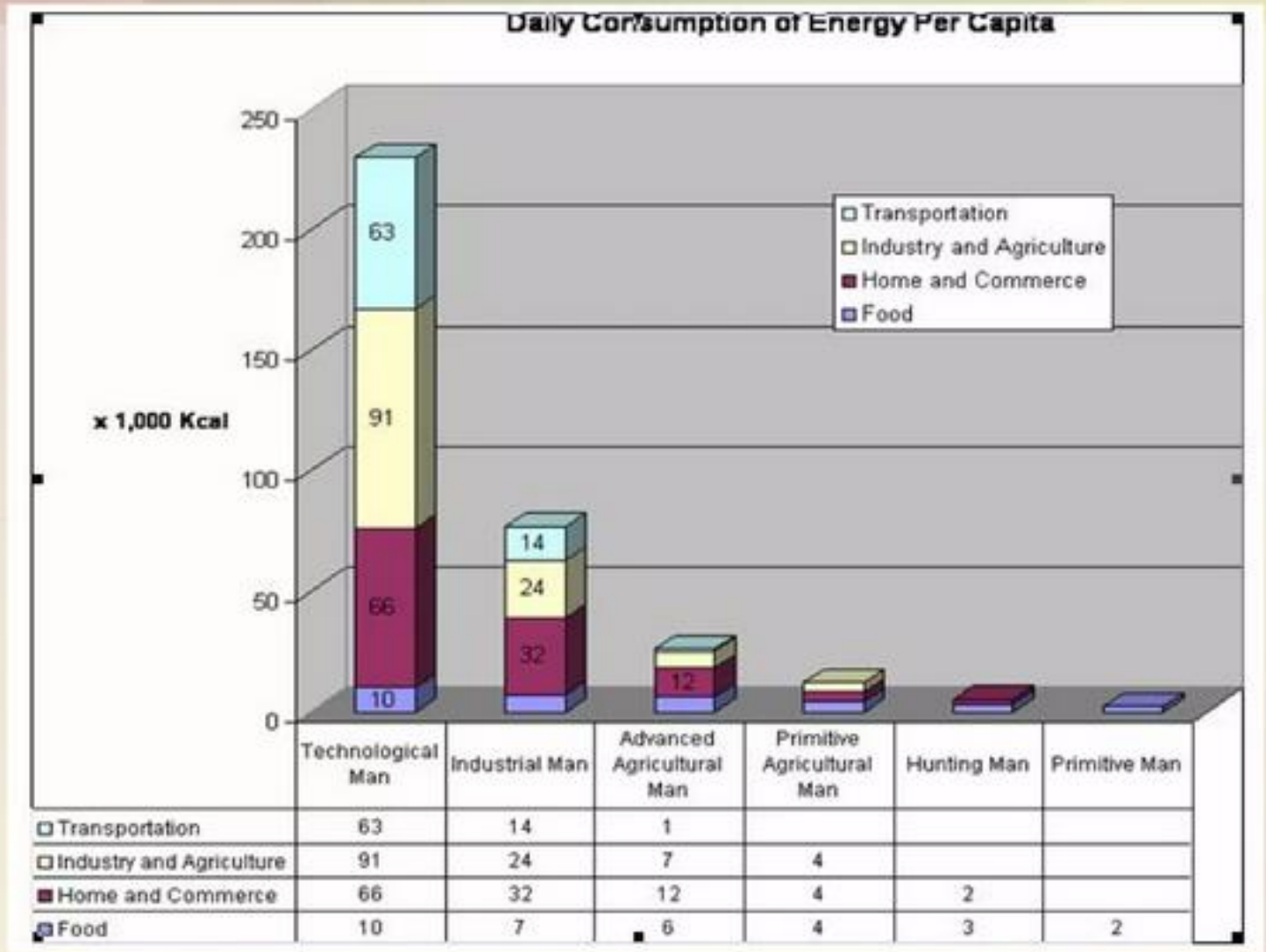
Some Interesting Facts



	Technological Man	Industrial Man	Advanced Agricultural Man	Primitive Agricultural Man	Hunting Man	Primitive Man
Transportation	63	14	1			
Industry and Agriculture	91	24	7	4		
Home and Commerce	66	32	12	4	2	
Food	10	7	6	4	3	2

Estimated Daily Consumption of Energy per Capita at Different Historical Points

Some Interesting Facts

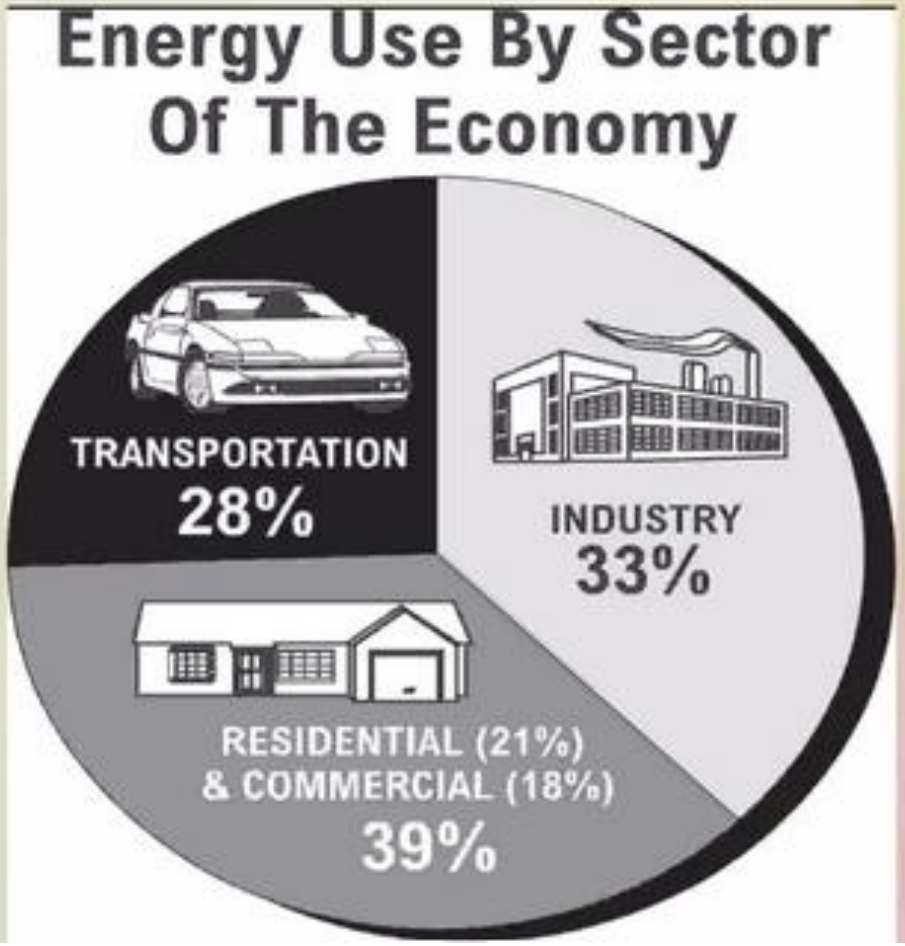
ENERGY UTILIZATION AFFECTS MODERNISATION

- Hence, the **age of Industrialization** and more so, the **age of Technology** have **accelerated** the **appearances and exploitation of new energy sources**.

- The **success of an industrial society** i.e., **growth of its economy**, **quality of life-style** of the population and the society's **impact on the environment**, is a **function of** the **quantities and types of energy resources it exploits** and **efficiency with which it converts potential energy into work and heat**. Increasing energy consumption closely matches societal modernization.

Energy Consumption Pattern

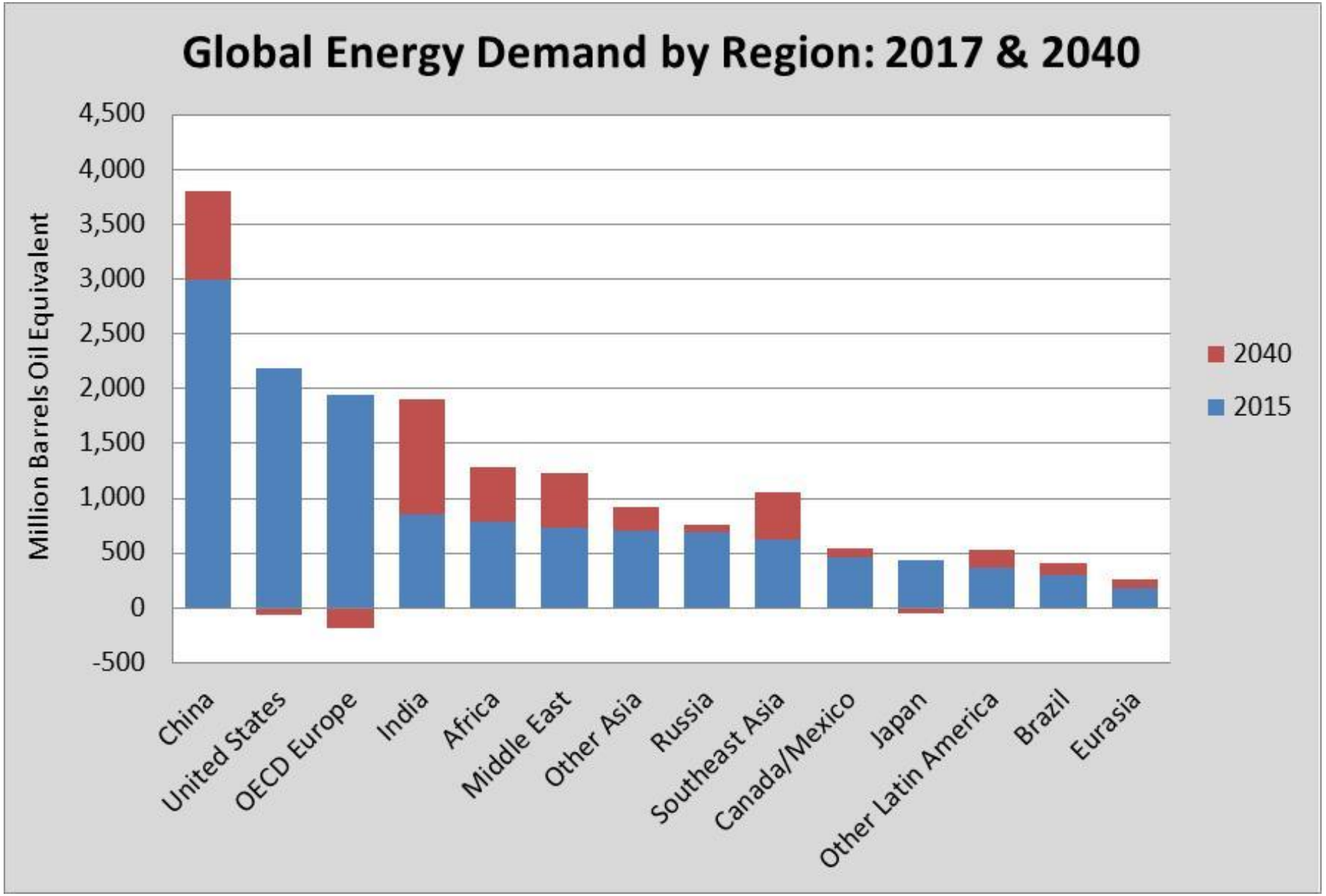
- USA has the largest per capita energy consumption in the world.
- As per an estimate in the US during 2008, energy consumption pattern observed in different sectors was as shown in Figure.



Some Interesting Facts

- **INDIA** ranks **sixth** in the world in terms of **Energy Demand** accounting for **3.5% of world commercial energy demand** in **2001**.
- The **per capita energy consumption** in India is **less** than that of most countries **(290 kg per capita)**, even less than that of neighboring Pakistan **(293 kg per capita)** as per the records in **April, 2001** at the Ministry of Environment and Forests, owing to high population.
- **By 2030**, the **population of India** will become **more than** that of **China** and **by 2050**, India will consume **1/3rd of the total global energy demand**.

Some Interesting Facts



Factors Effecting the Energy Demand

Following factors accelerate the energy demand :

- **Population growth.**
- **Rapid urbanization**, increasing population density as well as space constraints.
- **Global warming** – a major environmental challenge before the mankind, which calls for serious concern and actions.
- **Fast depleting Conventional Energy Sources**, which need conservation and which also add to the problem of global warming because of inbuilt environmental hazards associated with their usage.

Energy Sources

ENERGY SOURCES : According to usage

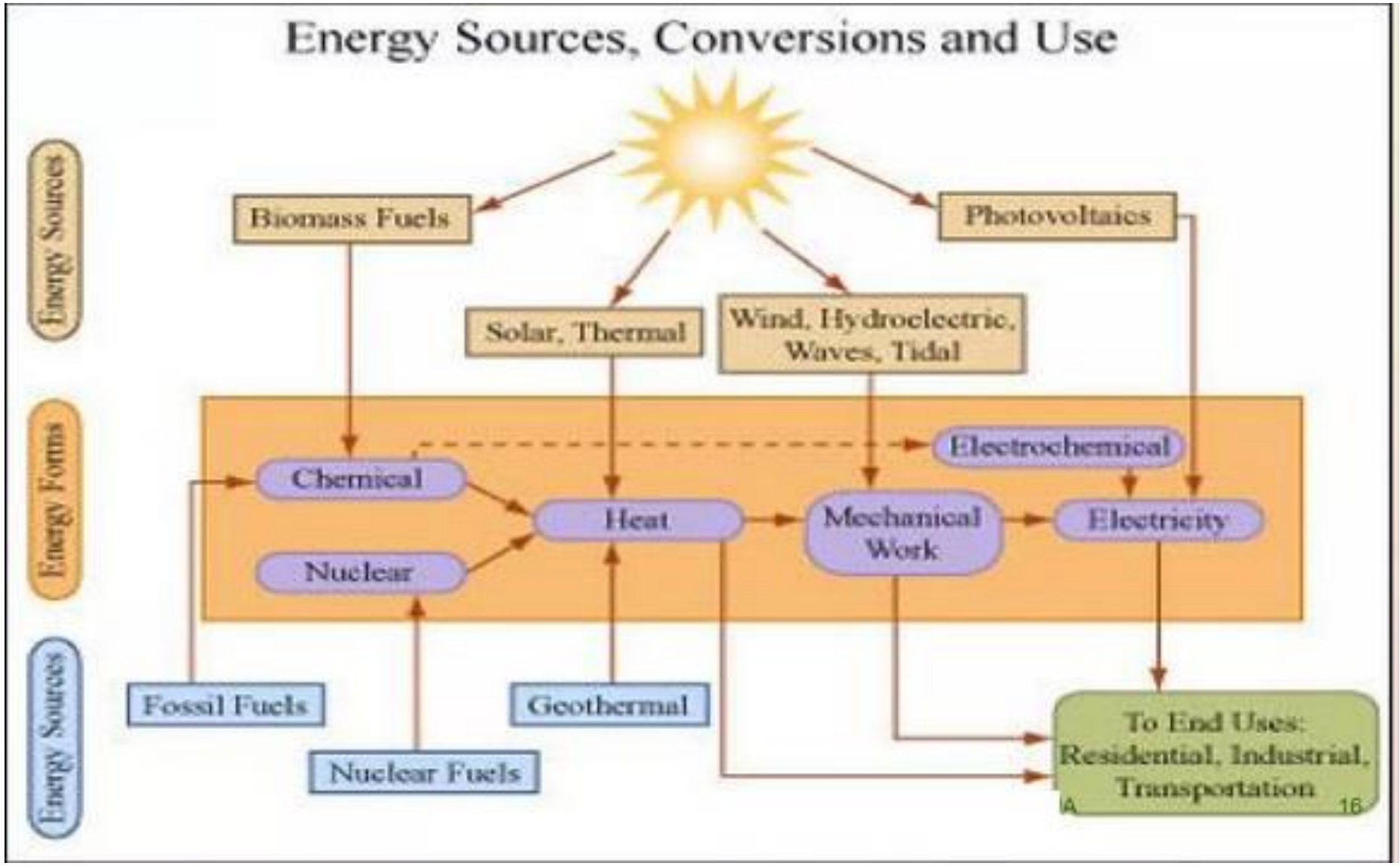
CONVENTIONAL ENERGY SOURCES

- Widespread use.
- High Energy Concentration.
- Harm Environment.
- Non-renewable, i.e. cannot be replaced / regenerated in short time.
- Limited and hence, need conservation.
- Fossil fuels, like Petrol, Diesel, Coal, Oil, Natural Gas, etc.

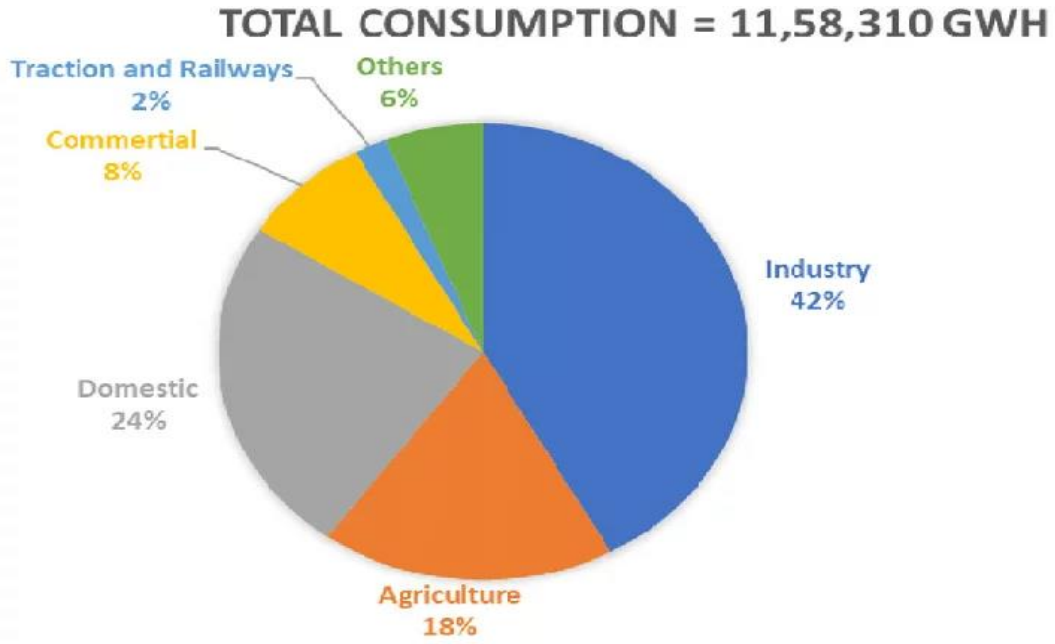
NON-CONVENTIONAL ENERGY SOURCES

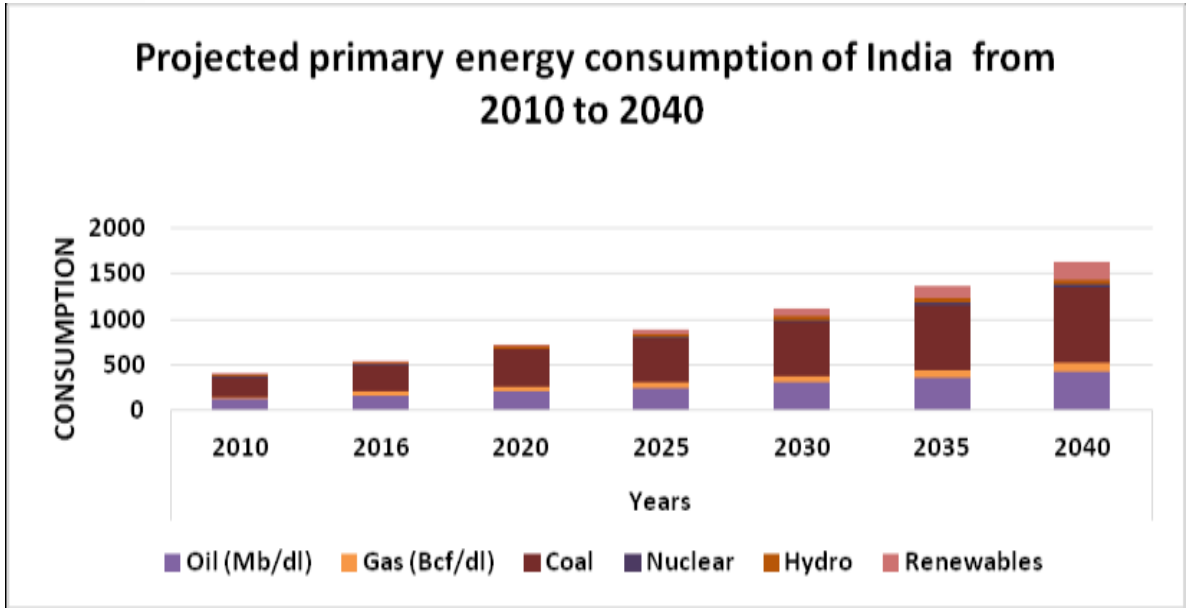
- Limited use.
- Low Energy Concentration.
- Environment-friendly.
- Renewable, i.e. can be replaced / regenerated in short time.
- Unlimited, abundantly available.
- Solar Energy, Wind Energy, Geothermal Energy, Hydro Energy, Tidal Energy, Ocean Thermal Energy, etc.

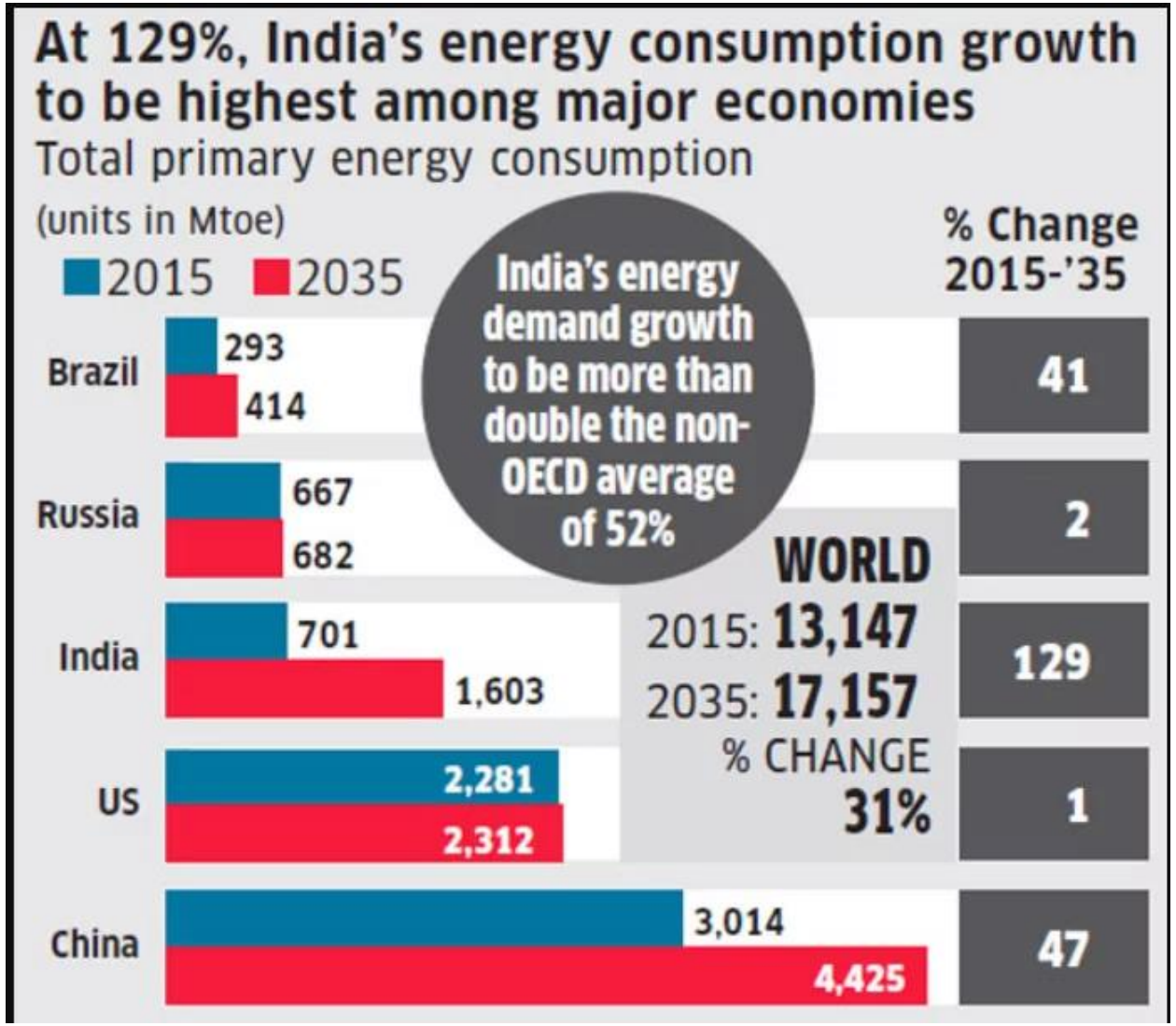
Energy Sources



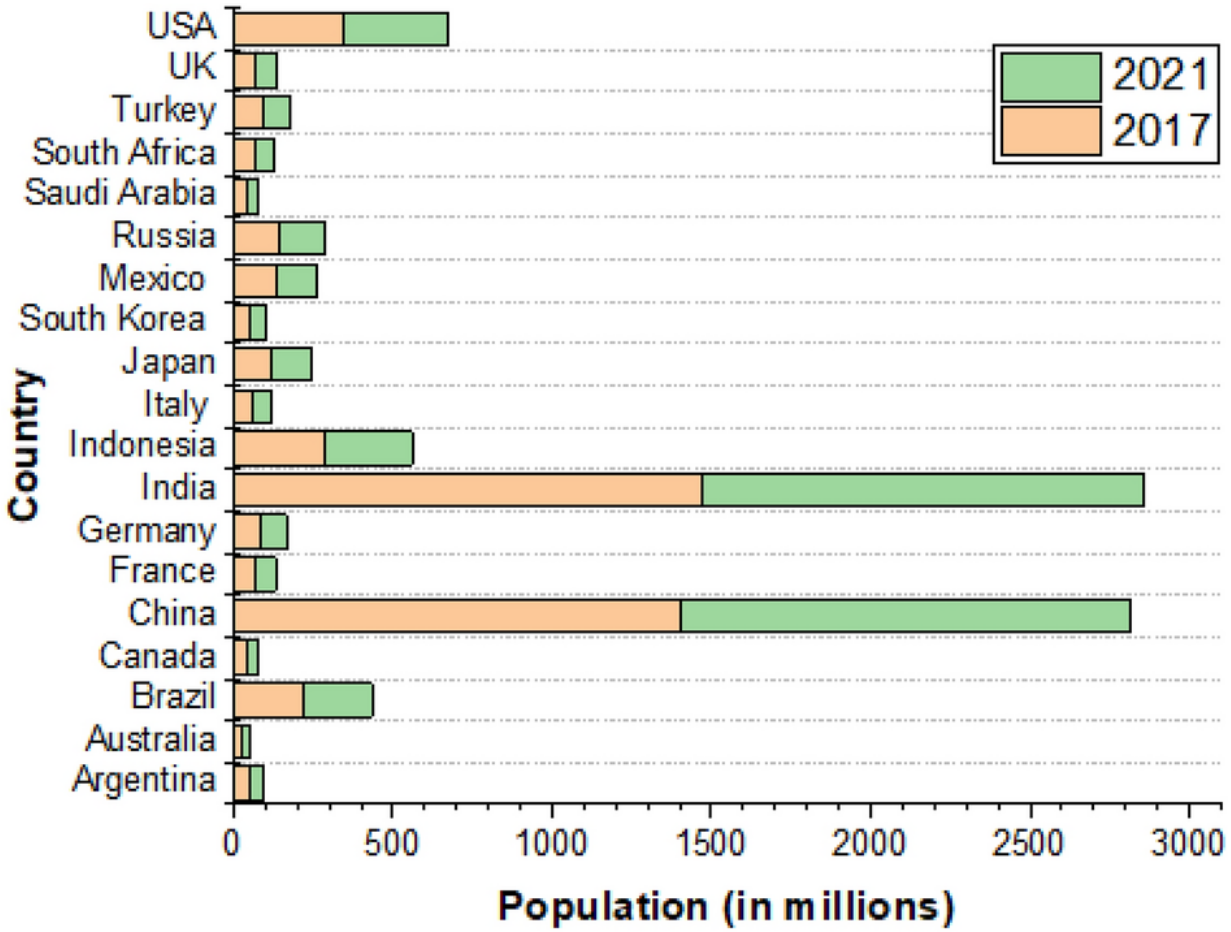
Energy Sources and Consumption in India

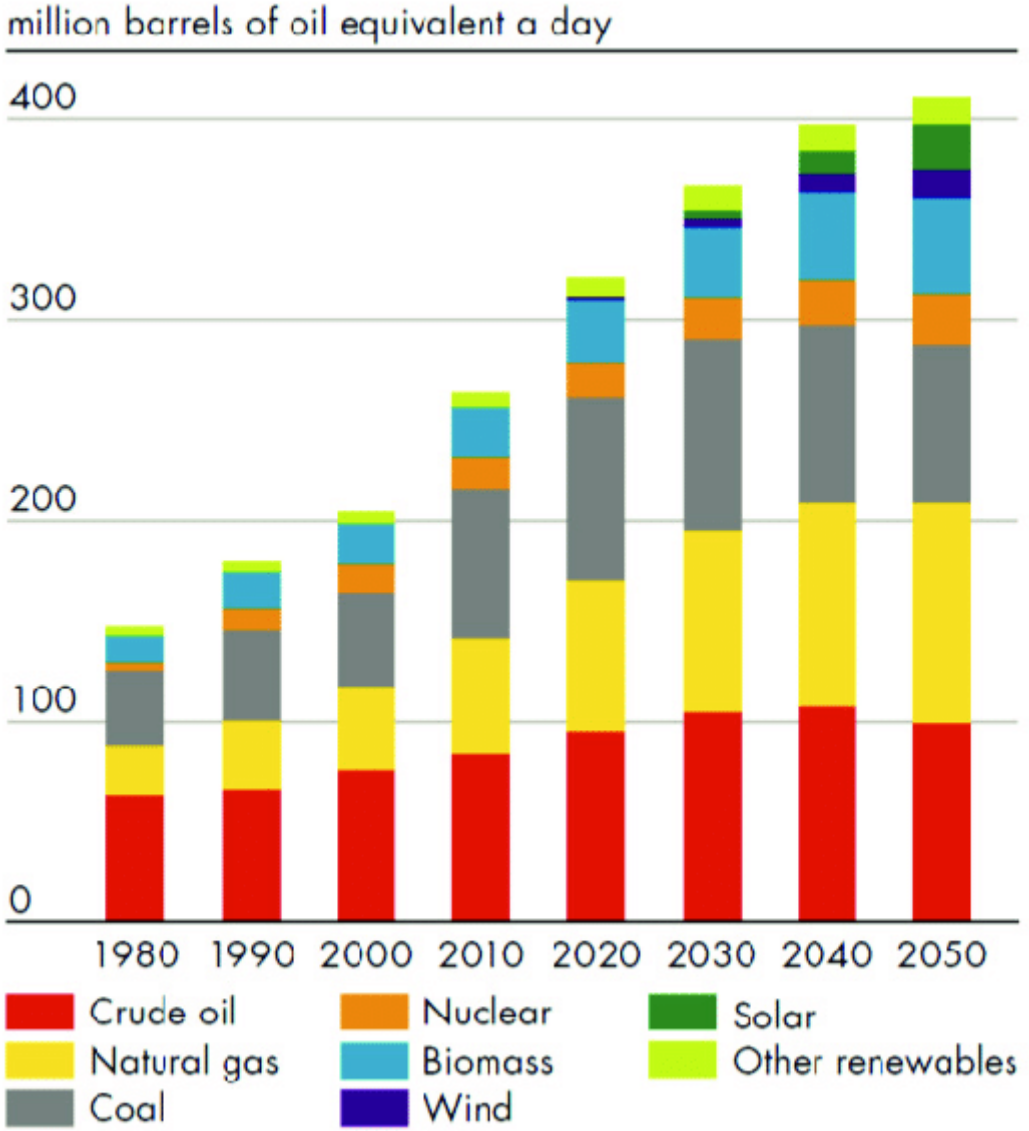






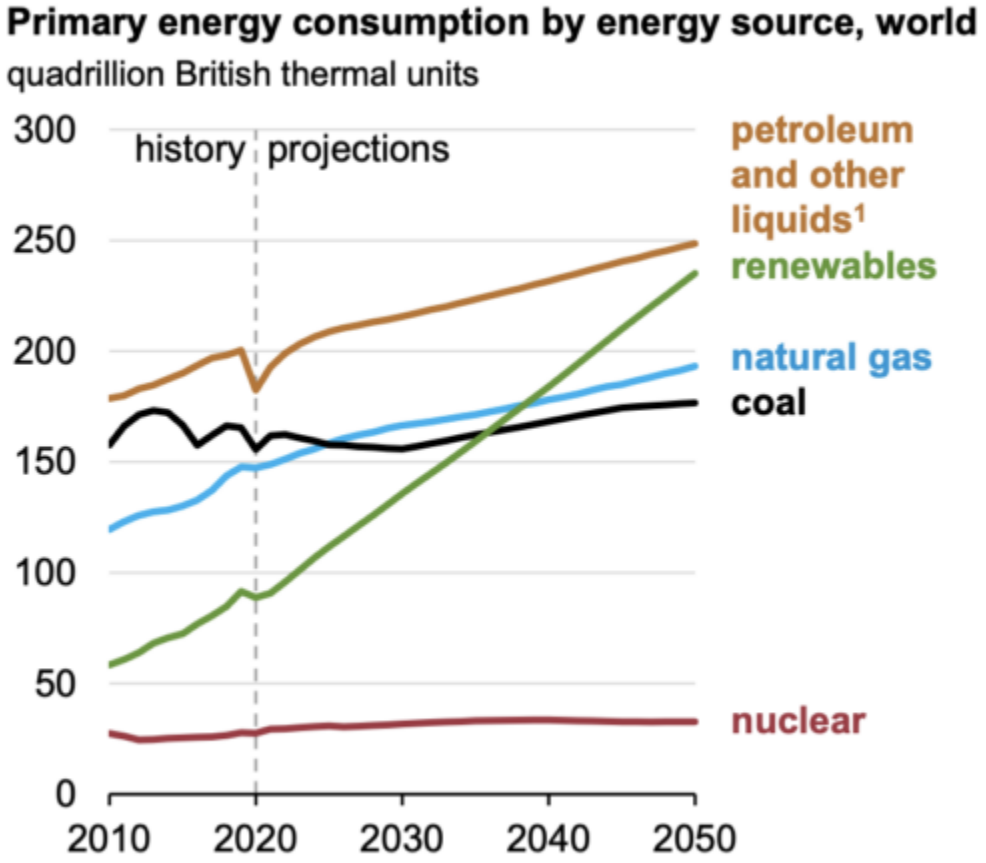
Energy Sources and Consumption



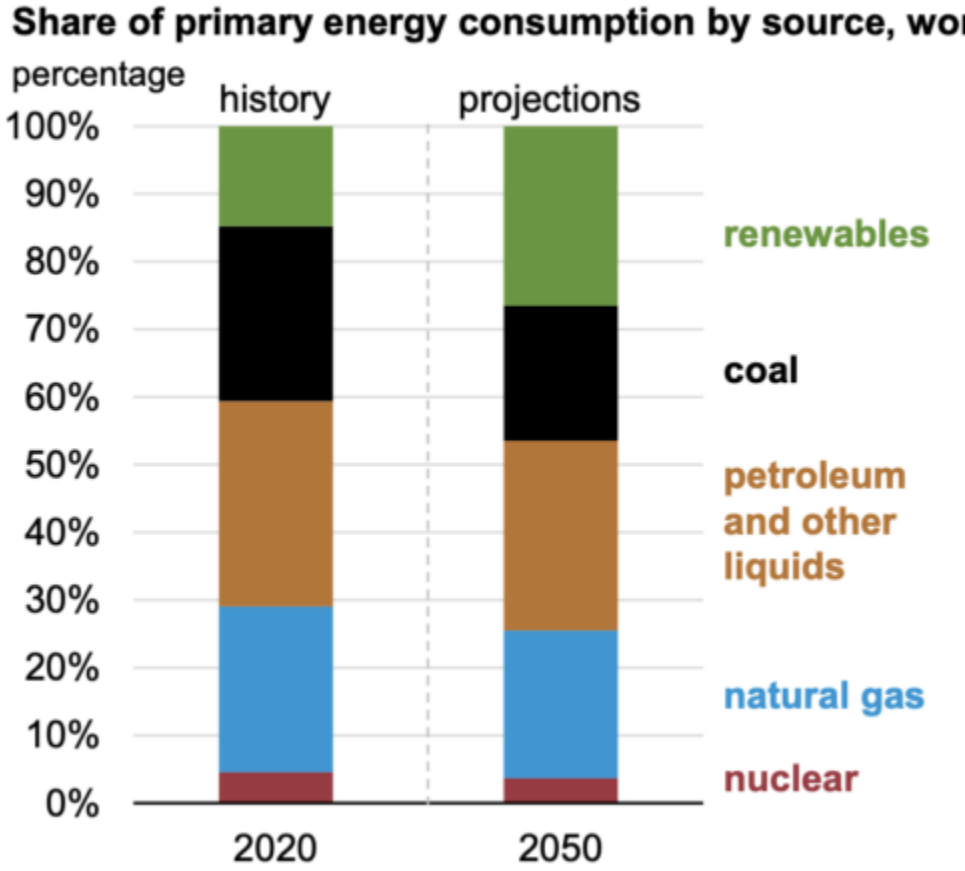


Energy Sources and Consumption

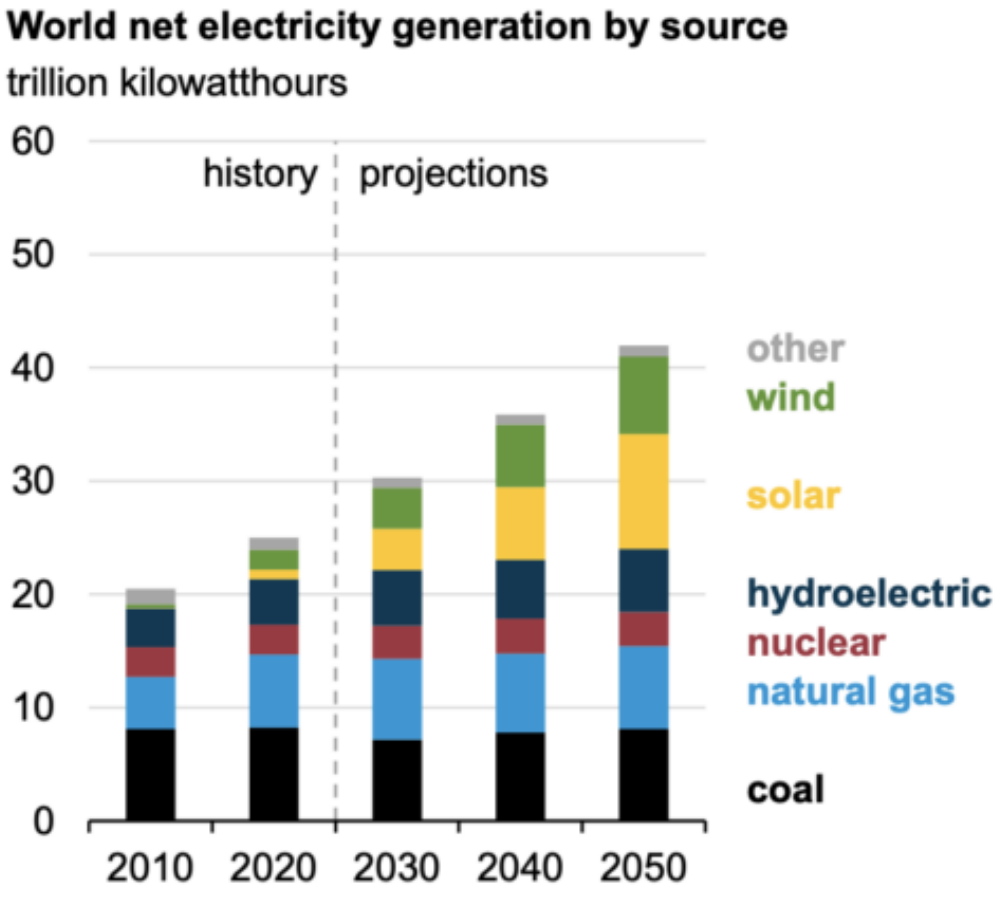
Primary energy consumption by energy source

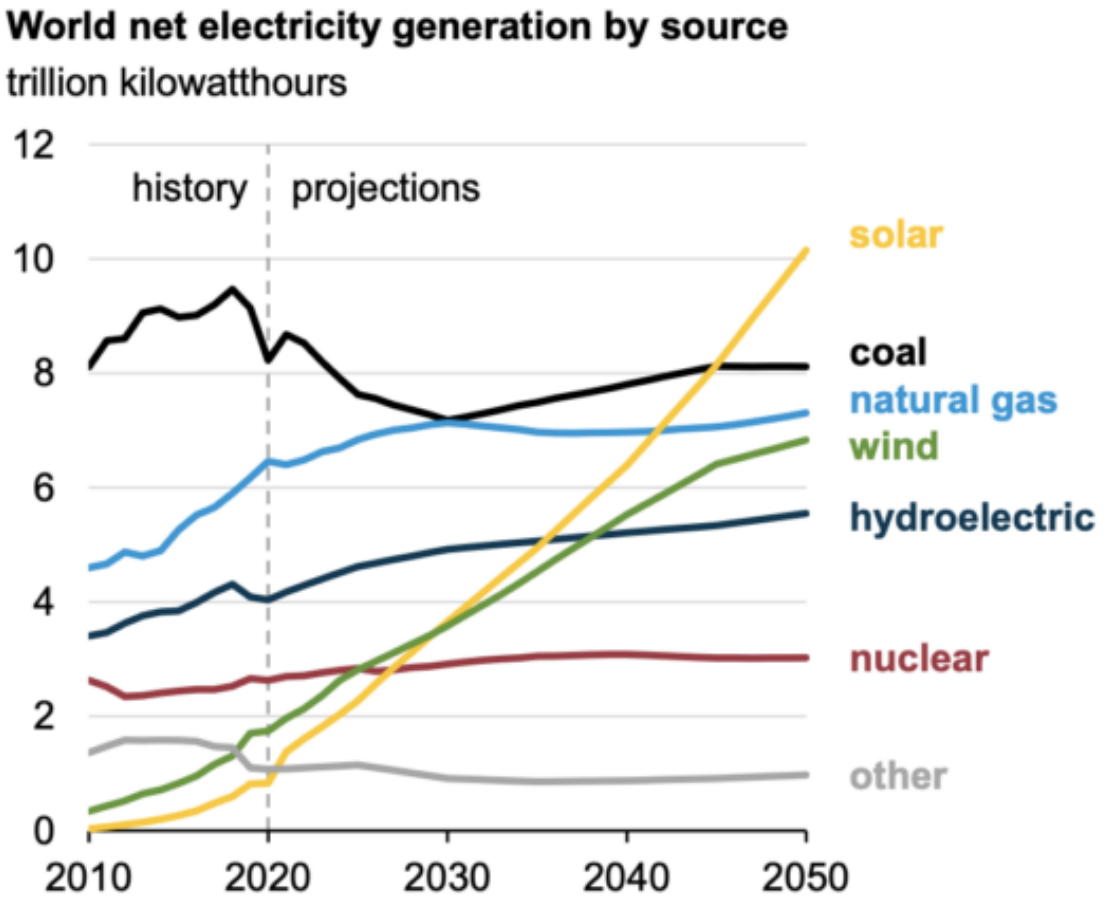


[1] includes biofuels



World net electricity generation by source





WHAT WE CAN DO ?

- **RECYCLE** - compositing waste materials into new products to prevent waste of potentially useful materials.
- Turn off all electronic devices that are not in use. Not only turn them off but try to remember to unplug them. You will be surprised how much you will save with this simple step!
- Replace old light bulbs with energy saving fluorescent bulbs. They may cost more, but will save you much more in the long run.

Actions……

At Home

- We should not keep lights unnecessarily switched on.
- Reduce the energy your appliances consume by analyzing star ratings.
- Improve your water heating efficiency to reduce energy costs.

At Public Places

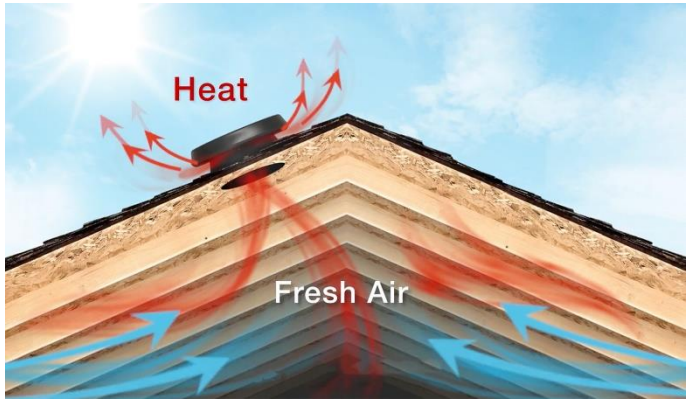
- Switch of the fans and lights in the places like bus terminal and railway stations when not necessary.
- Switch off the street lights.
- Big Hoardings, lightened up for the whole evening and nights are other wastage of power which can be and should be avoided

Actions……

REDUCING ENERGY CONSUMPTION

(at local level)

- Look for the "Energy Star" logo.
- Use smaller kitchen appliances.
- Use lids on pots and pans to reduce cooking times.
- Switch to compact fluorescent light bulbs.
- Remember that it pays to invest in energy efficiency.
- Keep curtains and blinds closed at night.
- Install more attic insulation.
- If your basement is unheated.
- Maintain your central air conditioner by cleaning the outside compressor.
- During late afternoon and early evening, turn off unnecessary lights.
- If your home can't accommodate central air conditioning, try a whole-house attic fan.
- During the winter, remove window air conditioners.
- Reflective window film.



ENERGY STAR

Conclusion

- **Energy** is **basic need** of Life.
- Any **happening or activity** in the Universe involves **conversion of Energy** from one form to another.
- Throughout history, man has **developed ways** to expand his ability to **harvest energy**.
- **After Industrialization**, the **rate of Energy Consumption increased dramatically.**

Conclusion

- Industrial Revolution lead to unlocking of Earth's vast **concentrated storage deposits** - **coal, gas and oil,** and Man was no longer dependant on and **limited to natural energy flows**.
- The Development of a country dependent upon its Energy Sector.
- Energy Consumption Rates and Patterns govern the modernization of a society.

Conclusion

- The Energy needed for various needs is provided by ENERGY SOURCES.
- There are two types of Energy Sources according to Usage – **Conventional Energy Sources** and **Non-conventional Energy Sources**.
- Conventional Energy Sources are fast depleting and also give rise to environmental hazards.
- Hence, need for **Alternative Energy Sources** like Solar Energy, Wind Energy, Biomass Energy, etc.

RENEWABLE ENERGY SOURCES AND CLASSIFICATION

RENEWABLE ENERGY RESOURCES

RENEWABLE ENERGY

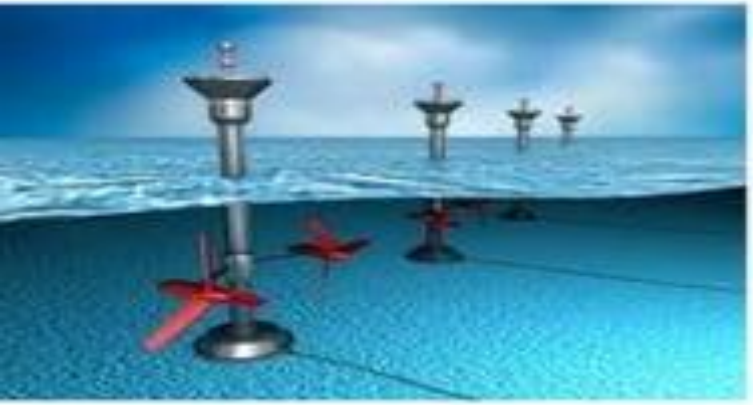
The energy resources which can be used to produce again and again are known as renewable energy resources.

- **There are many different forms of renewable energy.**

- Solar energy
- Wind energy
- Ocean thermal
- Geothermal energy
- Biomass or biogas energy

Solar energy

Wind energy



Ocean thermal

Geothermal energy

Biomass or biogas energy

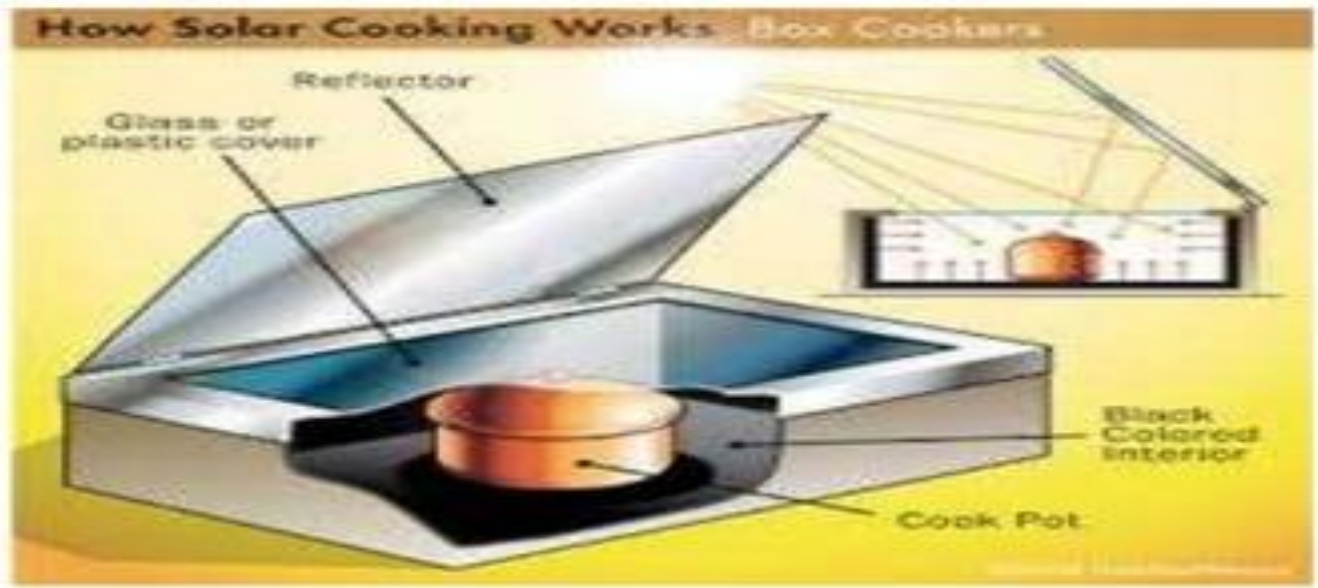
SOLAR ENERGY

Solar energy is the energy, the earth receives from the sun, primarily as visible light and other forms of electromagnetic radiation.

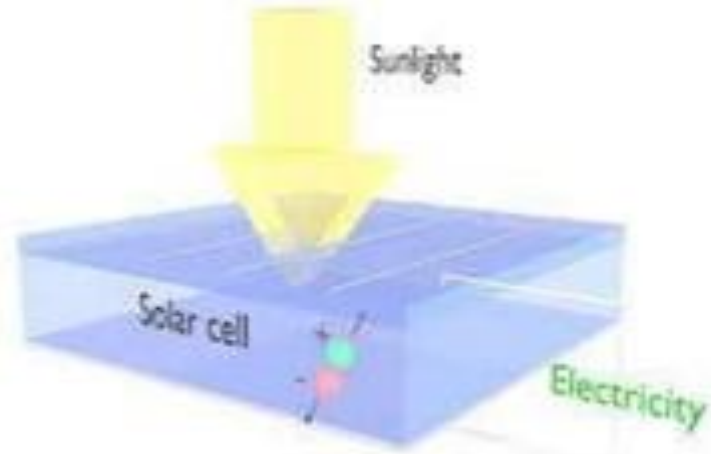
➡ Solar energy can be converted into electrical energy by using solar plates.

➡ **Examples:**

- solar cooker
- Solar heater
- Solar call



Solar heater



➡ **Advantages:** solar cell

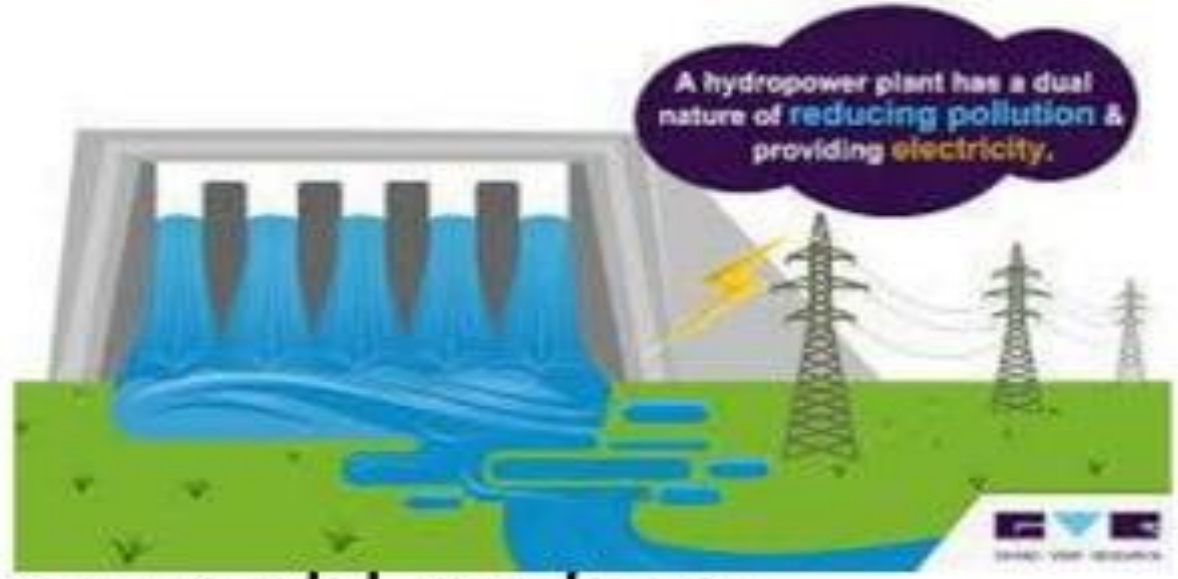
- Solar energy doesn't produce carbon dioxide.
- It does not effect our environment.

➡ **Disadvantages:**

- It is not constant ,it depend on weather condition ,time and location.

WIND ENERGY

- Wind power is good renewable, clean and free source of energy for power production.
- Reduce dependence on fossil fuels including imported oils.
- Reduce emission of greenhouse gas and other pollutant.
- One major concern is the noise – be improved.

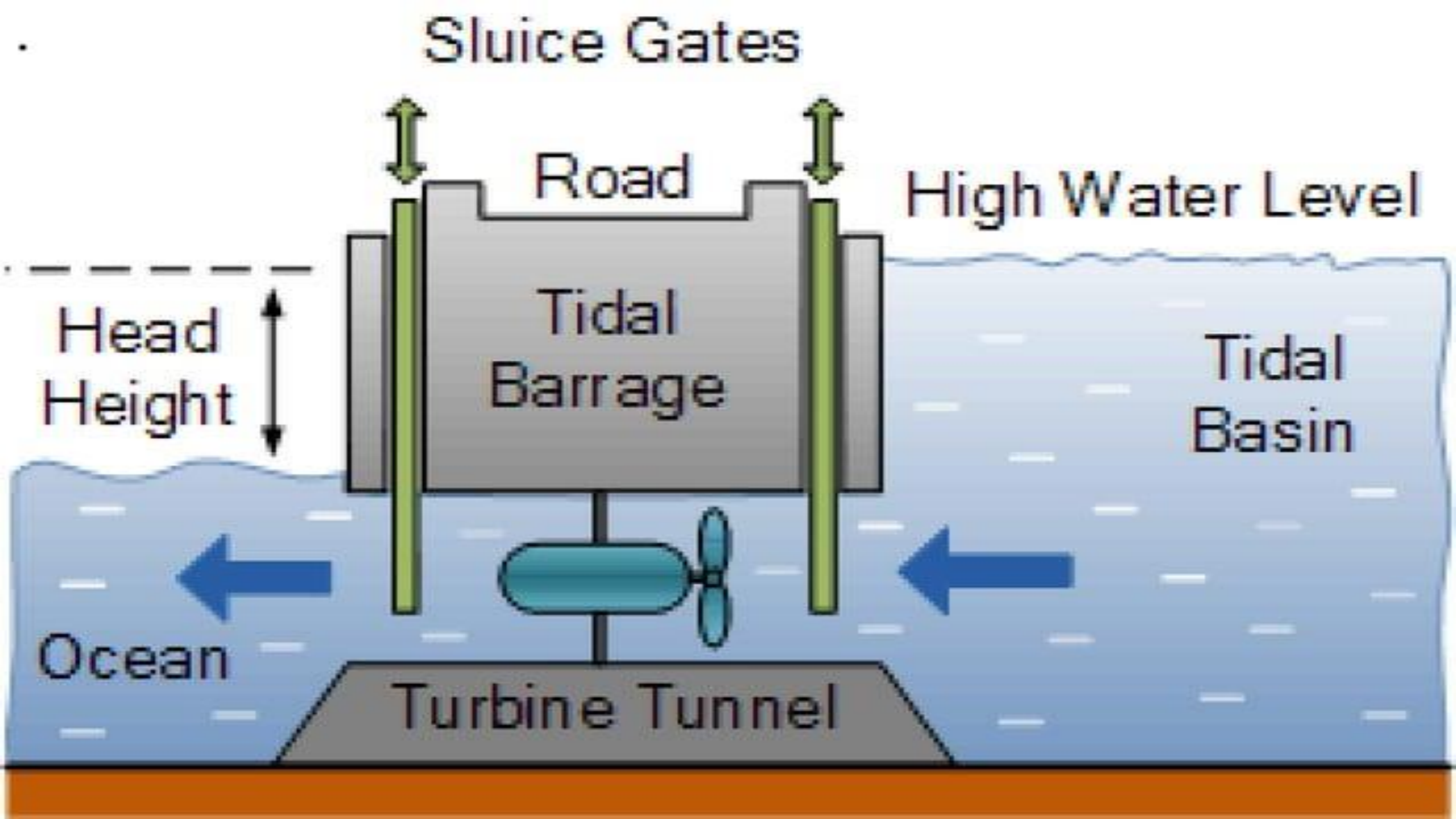


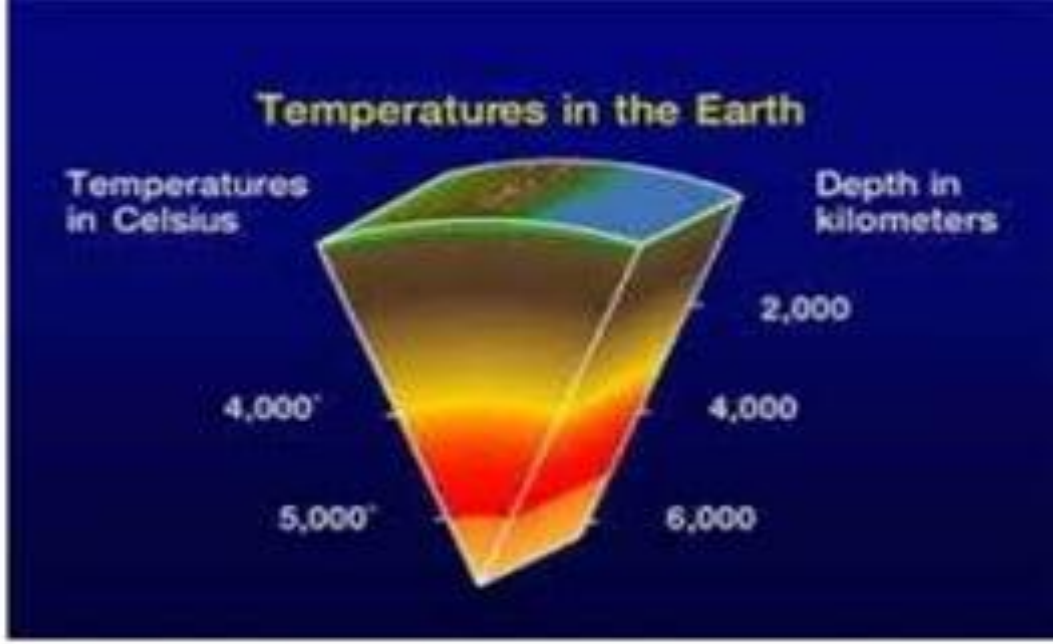
OCEAN THERMAL

- The oceans cover 75% of the world surface.
- It is the largest renewable energy source available to contribute to the security of energy supply reduce greenhouse gases emission.

→ **THE OCEAN CONTAIN TWO TYPE OF ENERGY**

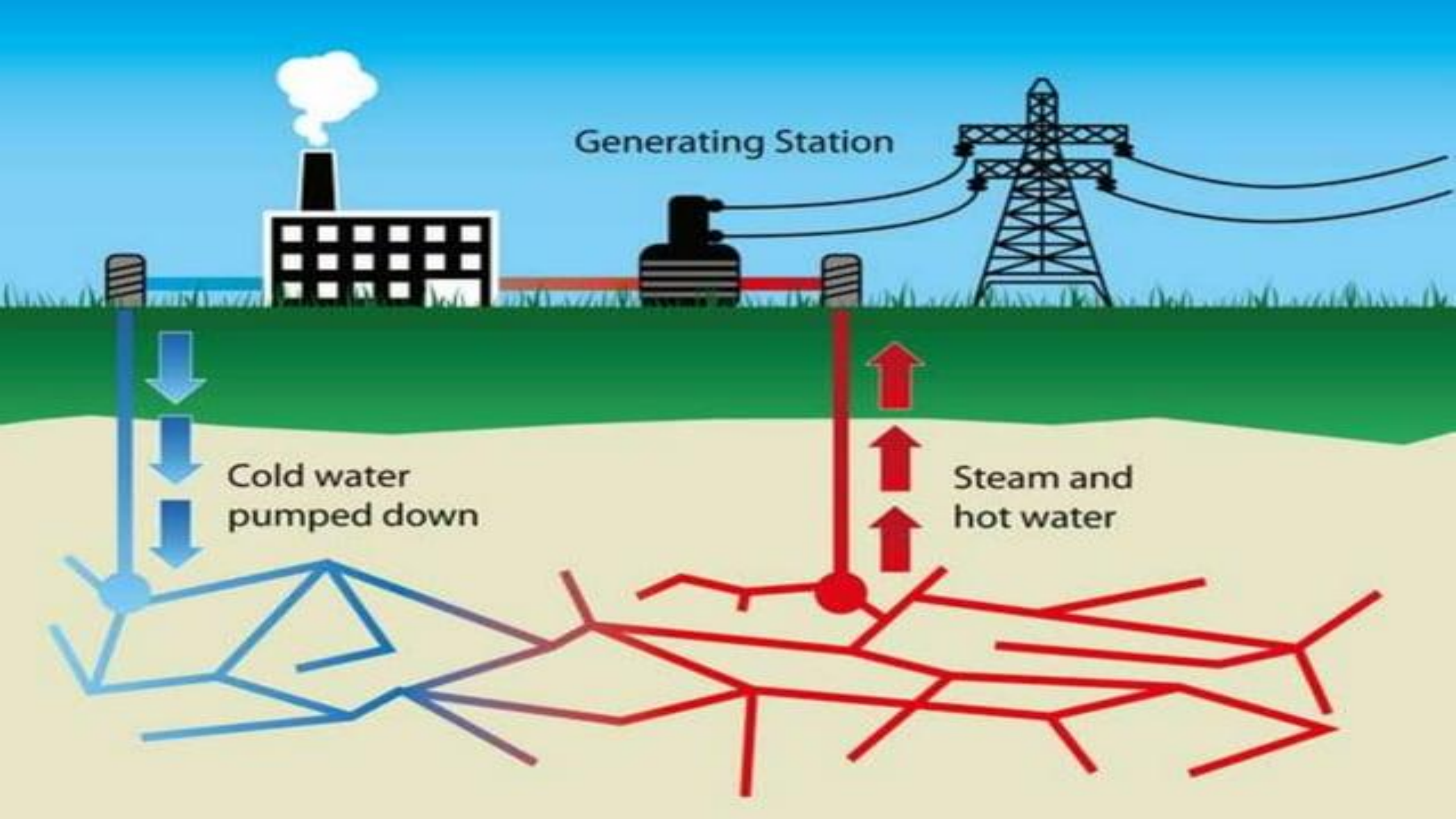
- Ocean thermal energy conversion from the sun's heat.
- Mechanical energy from tides and waves.


Sluice Gates
Road
High Water Level
Head
Height
Tidal
Barrage
Tidal
Basin
Ocean
Turbine Tunnel



GEOTHERMAL ENERGY

- Geothermal energy is the heat from the Earth. It's clean and sustainable.
- Resources of geothermal energy range from the shallow ground to hot water and hot rock .
- It found a few miles beneath the Earth's surface, and down even deeper to the extremely high temperatures of molten rock called magma.
- Geothermal heat pumps can tap into this resource to heat and cool buildings.


Generating Station
Cold water
pumped down
Steam and
hot water

What's biomass energy?

- Rapidly increasing the population and industry causes more energy need.
- Biomass is one of primary sources which can be used to provide renewable and clean energy.
- Biomass energy is unending and can be obtained everywhere. Morever it helps the socio-economical development in country side.

					
Solar	Wind	Geo	Hydro	Bio	Tide

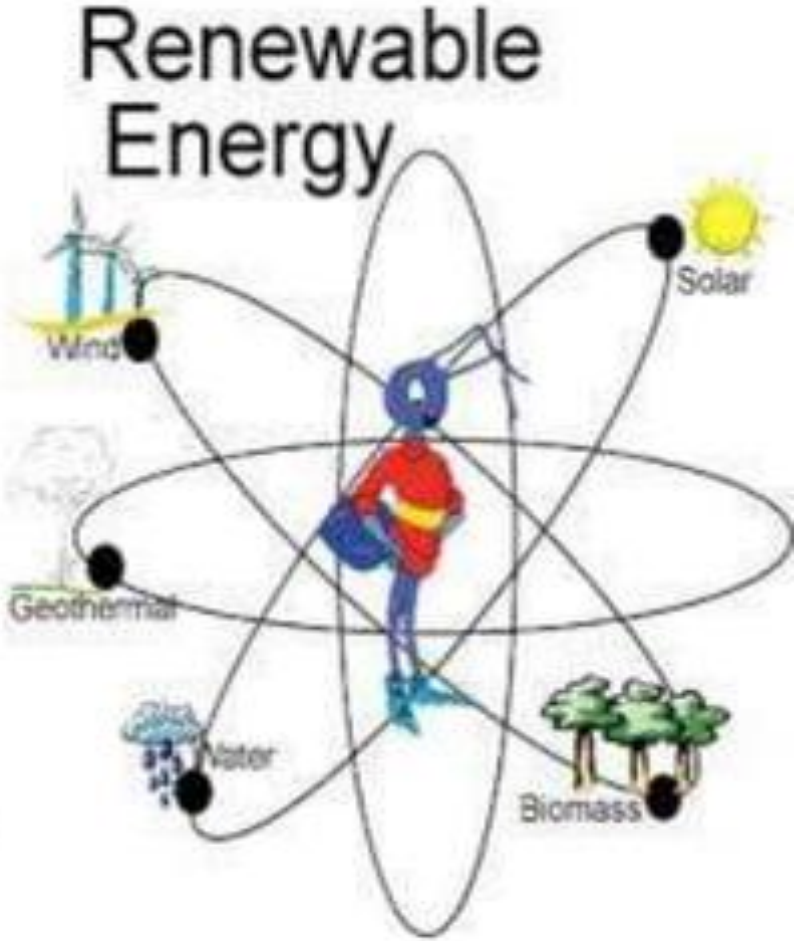
Biomass or biogas energy

- Biomass is a **renewable** source of fuel to produce energy.
- because: waste residues will always exist – in terms of scrap **wood**, mill residuals and forest resources; and.
- properly managed forests will always have more trees, and we will always have crops and the residual biological matter from those crops.

The Bio-Gas Digester:

WHY WE NEED ALTERNATIVE ENERGY SOURCES

- **Economical reason :**
  - Fossil fuels won't last forever.
  - Renewables provide new jobs.
  - Our country will be less dependent on other for fuel.



- **environmental reasons :**
  - renewable will decrease air pollution and greenhouse gas emissions.

DO YOU KNOW ? – FOSSIL FUELS CURRENTLY SUPPLY 80% OF THE WORLDS ENERGY BUT RENEWABLE ENERGY USE IS REPADILY GROWING.

Energy Sustenance

- Energy is now well recognized as an essential parameter of socio-techno-economic development of any system and it is presently used as the measure of the standard of living, quality of life, civilization, and culture of a country.
- Energy consumption dictates social inequalities and disparities between one country and the other. Conventional energy sources such as fossil fuels (coal, natural gas, and oil) and nuclear fuels (uranium and thorium) have been a resource of world energy needs since the Industrial Revolution.
- The fast depleting rate of conventional energy resources, climate change and environmental problems, and 1973 oil crisis forced the countries to redefine their energy development objective to use clean, affordable, and secure sources of energy to continue eco-friendly technological progress.
- Non-conventional energy resources from the sun (such as solar light, heat, and wind), the earth (such as geothermal, micro-hydroelectric, and bio-mass and bio gas), and the sea (such as tides, waves, and ocean thermal) are just some examples of energy sources that meet such objectives, and these energy resources have risen to the challenge of meeting the increasing energy demands of the present and future generations.

- This important energy resource is available in abundance in many countries but high cost of shale oil production and associated environmental problem have restricted their development.
- This chapter describe various aspects related with all the possible conventional and nonconventional resources, principles of conversion, pros and cons, applications, and storage of energy resources.

ENERGY SYSTEMS MODEL:

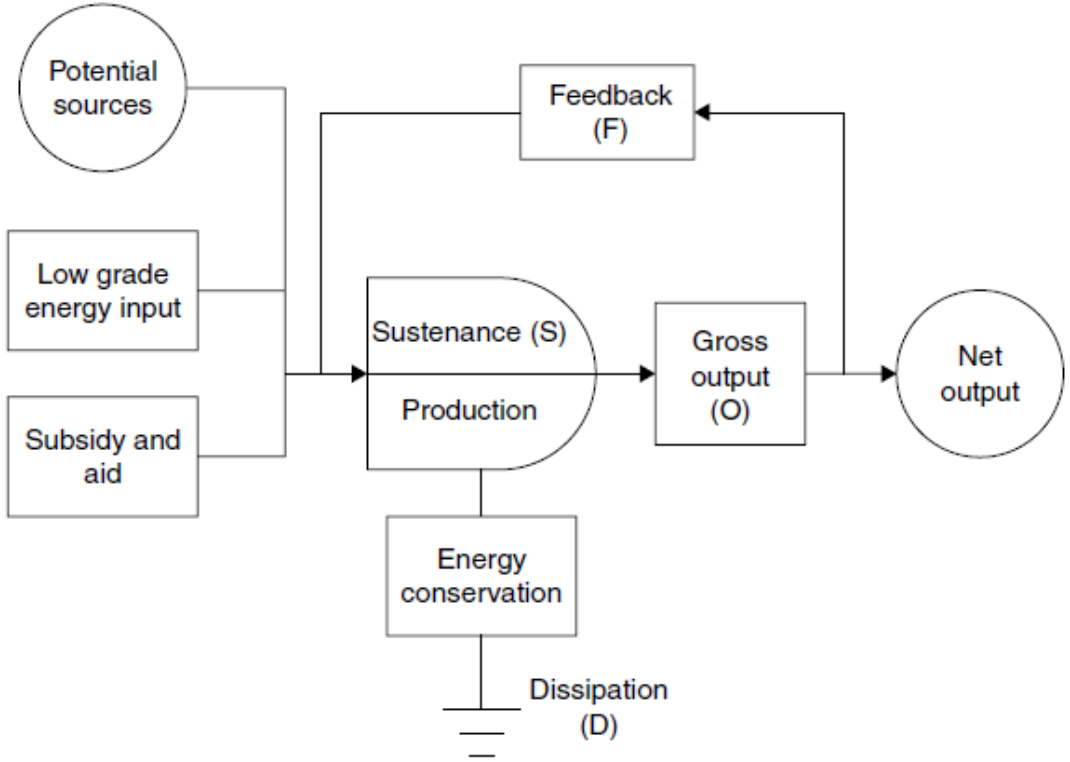


Figure 1.4 Energy system's model

1.Production and sustenance
2. Inputs
3. Outputs
4. Feedback
5. Dissipation

Production and Sustenance Activities:

- ✓ Every society or system is comprised of two important activities: sustenance and production. Sustenance activities relate with the social development that includes standard of living and lifestyle and to fulfil the indicator of quality of life, such as food, cloth, shelter, education, and health. However, these activities are not self-sustaining.
- ✓ They have to be sustained through continuous inputs either from within the system itself or from the outside or as subsidy from government and other agencies.
- ✓ Production activities relate with techno-economic development of the system. It is an important parameter of a system since it is self-sustaining and creates employment. Competitiveness in global market is a constraint for production activities.

Inputs:

Inputs to the system are as follows:

- *Low grade energy*: These are available at almost zero cost from agricultural land and forests. Early men could sustain their survival with such a meagre amount of energy. This has also caused deforestation and ecological imbalance. It has now become insufficient for any kind of development.
- *Potential sources of energy*: These are any material object available from the earth, the sun, and the sea that contain energy in abundance and transferable to a usable form. Further, it has tremendous impact on the system development as a whole.
- *Subsidy or aid from government or outside agencies*: This input may be useful for only in emergency for short duration. Such an input to the system should be avoided to the extent possible.

Outputs:

- Output includes industrial products and goods produced through rural and cottage industries. Energy comes in the form of money obtained by sales of products and goods in global markets.

Feedback:

- It comes in the form of money from the sale of output goods. A portion of output is fed back to the system for its development. Care should be taken that feedback be restricted to a portion of output only. Net output should be kept in reserved for emergency and adverse calamities.

Dissipation :

- Dissipation will always be present in any energy activity system. This is also referred to as degraded energy output of the system. It leaves the system as garbage, low-grade heat, smoke, etc., that damage the environment in terms of pollution.
- Waste energy recovery system converts waste into wealth. However, dissipation cannot be completely avoided by energy conversion system; further, it can be minimized to a large extent.

Expressing all the material objects of the energy system in same energy unit, the system can be expressed as follows:

Inputs + Feedback = Dissipation + Sustenance + Outputs

Or $I + F = D + S + O$ ----------*(1.1)*

From Equation (1.1), it can be analysed that the objective of improving standard of living conditions, lifestyles, and quality of life in any system, energy for sustenance must be raised Equation (1.1) also depicts that for techno-socio-economical development of system, input energy (*I*) to the system should be increased and dissipation (*D*) should be minimized to the extent possible. Thus, all the enhanced potential sources of energy inputs and waste energy recycling provide energy for sustenance (*S*) and outputs (*O*) resulting in overall development of system considered.

CAUSES OF ENERGY SCARCITY:

- While the whole world is in the grip of energy scarcity, several countries, including India also, are facing various associated difficulties for its techno-socio-economic development because of energy shortages and many more things.
- However, they have been further complicated by the energy dependence on the other countries. when 30% population is utilizing 70% of energy and 70% population is forced to live with the 30% of the remaining energy.

Following points may be considered as the principal causes of energy scarcity

Increasing Population:

- Undoubtedly, only 40–45% population constitutes child producing groups, worldwide population is increasing at an alarming rate. It is extrapolated that by the turn of 21st century, population will increase manifold (Malthusian population model).
- These populations are unevenly distributed worldwide. Africa shares the largest population growth rate, followed by South Asia and then by Europe.

Increasing Energy Usage or Consumption:

- The movement of civilization from early man to the present technological man was totally based on energy usage. Energy is constantly used at home, at work, and for leisure period of enjoyment.
- Energy maintains techno-socio-economic development. Energy provides the society with heat and electricity daily and motive power to industry, transportation, and modern way of life.

1. In homes, for lighting and cooking, domestic appliances, televisions, computers, etc.
2. In industry to power the manufacture of the products.
3. In transport system to power cars, trucks, ships, and aeroplanes for transporting peoples and goods.

An increase in the world population and consequent increase in energy consumption increases energy demands manifolds. World Energy Council has provided the most reliable prediction as shown in . This indicates that by 2050, the world population will nearly be doubled from the present level and will rise to about 10 billion. Likewise, energy demand is projected to be at least double than the present level (Energy council).

Table 1.3 Energy Use Scenario

% of population	70%		30%
% of energy usage	30%	70%	

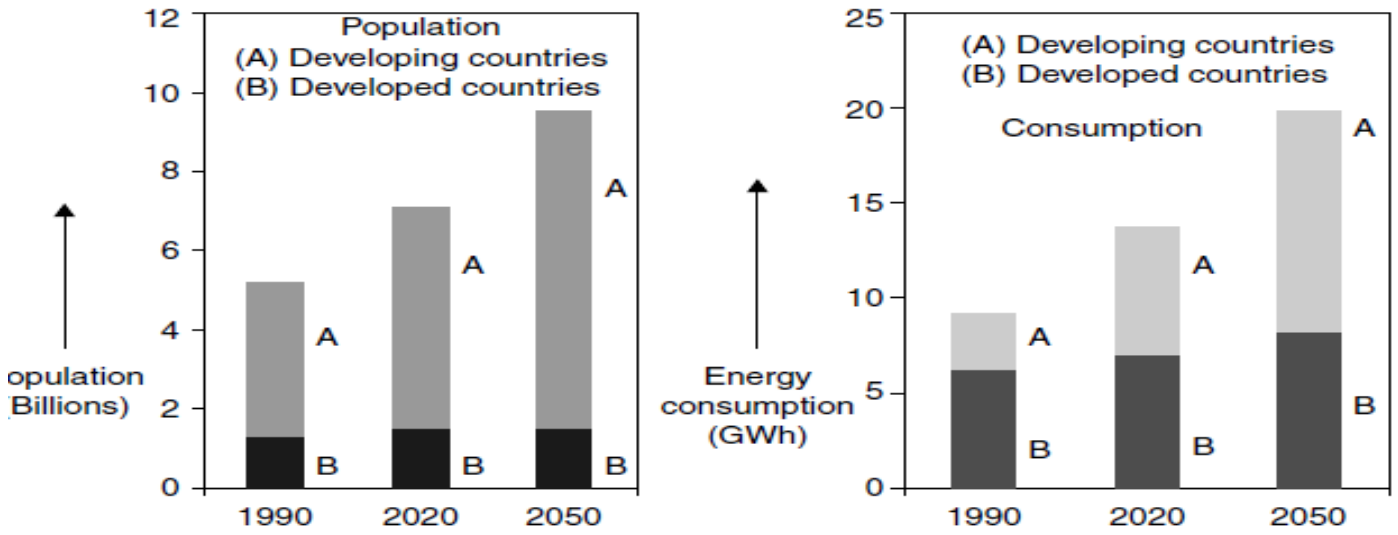


Figure 1.5 Population and energy consumption (Energy council)

Uneven Distribution of Energy Resources:

- It is well understood that very few wealthy countries have access to and actually use the largest part of the world's energy and material resources. The generation of environmental and social instability in several area of globe can be discussed in relation to the existence of disparity. Uneven distribution of energy and resource trade among countries is of paramount importance to environmental and political stability.
- For example, Middle East countries are full of crude oil reserves, but they are forced to involve in conflicts and wars and their energy reserves are forcefully used by wealthy countries. Geographical distribution is the main consideration for an unevenly distribution of fossil fuels (coal, oil, gas, and nuclear). Renewable energy flows are also spread out unevenly.
- Cloudiness in equatorial regions reduces solar radiation. Whole stretches of the continent have insufficient wind. There are very few sites with the best potential for geothermal, tides, or ocean thermal. In fact, a few densely populated region or area have no significant locally available energy sources at all.

Lacks of Technical Knowhow :

- Despite the fact that several countries or regions are having energy in abundance, they are not able to fully utilize them due to the lack of knowledge of conversion, transmission, distribution, and utilization. Because of the lack of technical knowledge, resources are mined and processed in resource enriched countries and then refined and used in developed countries.
- The price of exported resources is normally inadequate to compensate for the depletion of energy reserves and the environmental burden that is generated by resource extraction and primary processing in energy enriched countries. However, resources drive significant economic and environmental benefits in techno-economically developed countries.

1.6 SOLUTION TO ENERGY CRISIS OR SCARCITY

Owing to the growing importance of energy awareness, efforts should be systematically diverted in the following directions to tackle the gigantic energy crunch problems:

1. Minimizing population growth exploitation and harnessing the large utilization of known and unknown energy reservoirs.
2. Development of energy conversion techniques to convert basic energy available from energy reservoirs (primary energy resources) to usable form of energy (secondary energy resources). Usable energy form should be such that it is easy to generate, control, transport, and utilize. Electrical energy being the one and only usable form of energy to meet all these at present. Hydrogen energy and heat energy are other usable energy forms that are also being projected.
3. Keep the new energy system pollution free as far as possible, thereby environmentally acceptable to human beings.
4. The development of cheap and reliable energy storage systems. Maintaining new energy development program that is independent of foreign impact to the extent is possible.
5. Energy management.

FACTORS AFFECTING ENERGY RESOURCE DEVELOPMENT:

1. Energy or Fuel Substitution or Scale of Shift

- Today, there is no readily available energy resources that is large enough to substitute for fossil fuels (coal, oil, gas, and nuclear) at requisite scale. Undoubtedly, solar energy is several orders of magnitude larger than any conceivable global energy demand (about 1017 w). Practical conversion to electricity using photovoltaic or large scale industrial heat are quite negligible.

2. Energy Density

- The amount of energy contained in a unit of material object (energy resource) is termed as energy density. Air-dry crop residue (mostly straw and agricultural waste) contain only 12–15 MJ/kg. For example, the energy density of good quality coal is twice as high (i.e., 25–30 MJ/ kg) as that of crude oil (i.e., 42–45 MJ/kg).

3. Power Density

- Power density refers to the rate of energy production per unit of earth's area and usually expressed in watts per square meters (w/m2). Owing to lengthy period of formation (from biomass to coal and then from coal to hydrocarbons), fossil fuel deposits are an extraordinarily concentrated source of high quality energy.
- They are commonly produced with power densities of 102 or 103 w/m2 of coal or hydrocarbon field, and hence, only small land areas are required to supply enormous energy flows. In contrast, biomass energy production has densities below 1 w/m2, while density of electricity produced by water and wind is below 10 w/m2.
- Only photovoltaic electricity generation can deliver larger than 20 w/m2, although the cost and performance are the constraints of mass utilization.

4. Intermittency

- Growing demand for fuels, energy, and electricity fluctuates daily and seasonally in modern civilization. Further, the base load, which is defined as the minimum energy required meeting the demand of the day, has been increasing.

- Easily storable high-energy density fossil fuels and thermal electricity generating stations that are capable of operating with high load factors (775% for the coal-fired stations, 790% for nuclear plants) meet these needs.
- On the other hand, wind and direct solar radiation are intermittent and far from practicable. They can never deliver such high load factors. Photovoltaic electric generation is still so negligible to offer any meaningful averages.
- The annual load factors of wind generation in countries with relatively large capacities are 20–25%. Unfortunately, we still lack the means for storing wind or solar-generated electricity on a large scale.

5. Geographical Energy Distribution

- There are uneven distributions of fossil fuels and the non-fossil fuels (solar, wind, etc.). Cloudiness in the equatorial zone reduces direct solar radiation. Whole stretches of continent has insufficient wind. There are very few sites with the best potential for geothermal, tidal, or ocean energy conversions.

Based on the abovementioned five basic considerations, energy sources can be considered possible, probable, and practicable as given in Table

Sources	Possible	Probable	Practicable
Solar light	Yes	Yes	Yes
Solar heat	Yes	Yes	Yes
Wind	Yes	Yes	Yes
Water power	Yes	Yes	Yes
Fusion	Yes	Yes	Yes
Fission	Yes	Yes	No
MHD	Yes	Yes	No
Geothermal	Yes	Yes	Yes
Biomass	Yes	Yes	Yes
Sea waves	Yes	Yes	Yes
Sea tides	Yes	Yes	Yes
OTEC	Yes	Yes	No
Super conducting Gen. and Transformer	Yes	Yes	No
Thermionic	Yes	Yes	No
Thermoelectric	Yes	Yes	Yes