



ENVC 24 : Energy and Environment

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Course Web : <https://amitbny.github.io/akb.github.io/enerenv.html>

Course timeline : Feb–June, '18

Evaluation : Weekly/monthly assignments followed by final examination



Course: Marks - 25; Credit - 2

- General overview ➡ Sun as a source of Energy, Solar Radiation & its Spectral Characteristics, Conventional & Nonconventional Energy Sources, Fossil Fuels – Classification, Composition, Physico-Chemical Characteristics & Energy Content of Coal, Petroleum and Natural Gas.
- Nuclear Energy ➡ Fission & Fusion, Bioenergy – Energy from Biomass and Biogas, Anaerobic Digestion.
- Non-Conventional Energy ➡ Principles of Generation of Solar, Hydropower, Wind, Geothermal & Ocean Energy, Solar Collectors, Solar Pond, Photo-voltaic, Energy Use Pattern in Different Parts of World and in India.
- Energy Measurement ➡ Energy Consumption, Energy Conservation, Increased Efficiency & Cogeneration, Energy Policy, Management of Nuclear Energy Wastes, Research & Development on Renewable Energy, Energy Conservation Policy.
- Environmental Implication of Energy Use ➡ Green-house Gas Emission, Global Warming.
- Energy Security & Energy Budget of the Earth.

Energy and Environment

- Why should we study? If asked a few decades back, probably there were not so strong support.

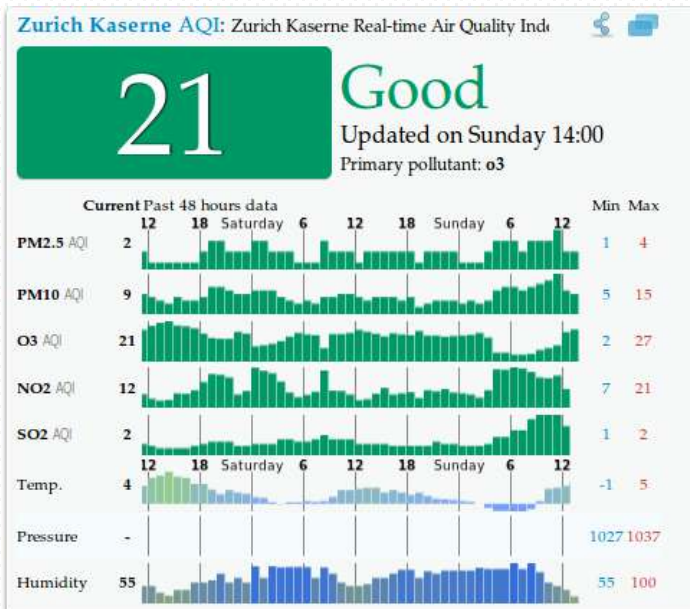


Earth recorded
from Apollo 17
crew in 1972
(NASA)

Energy and Environment

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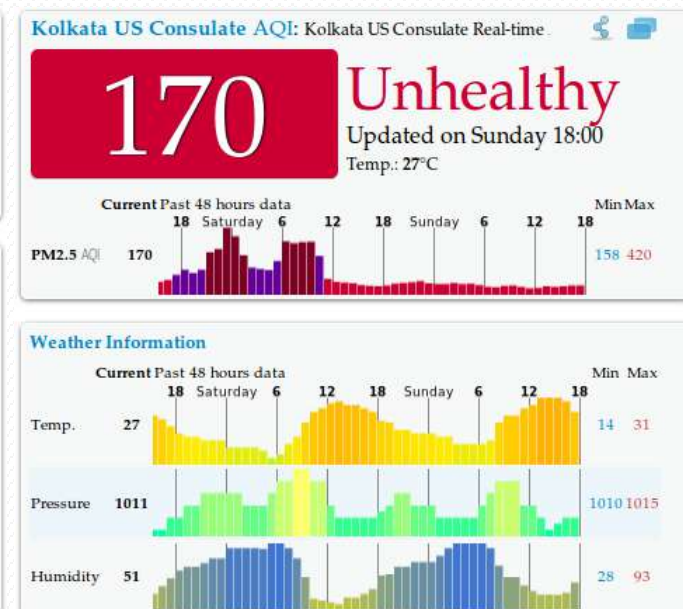
AQI (air quality index) as on 04/02/2018



Zürich, CH



New York, USA



Kolkata, India



Zürich, CH



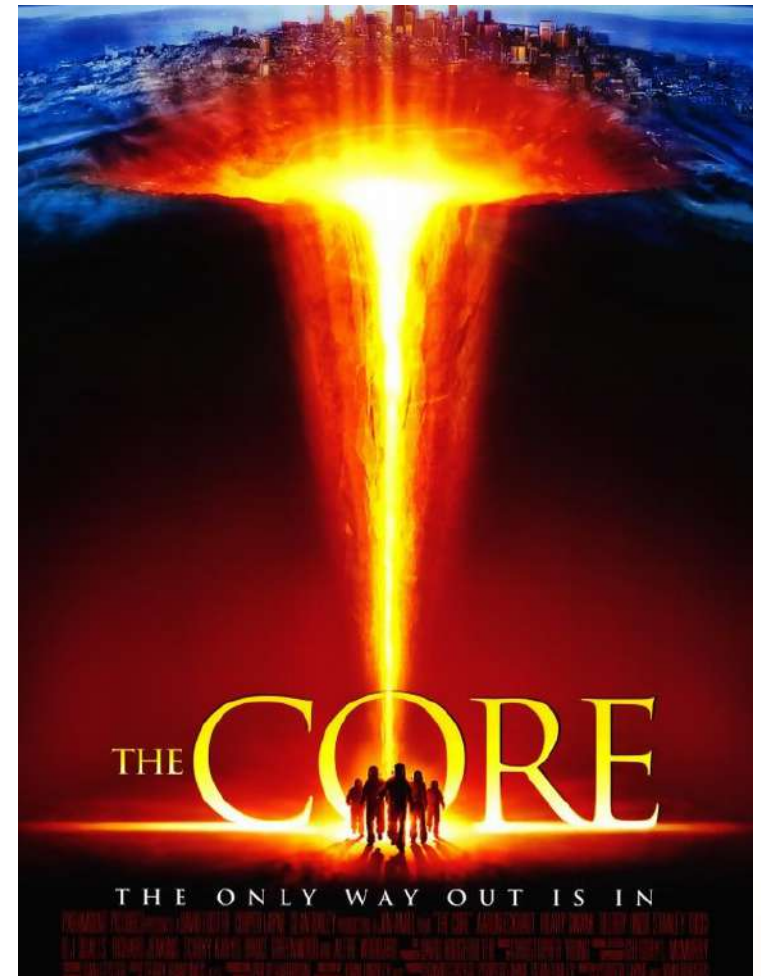
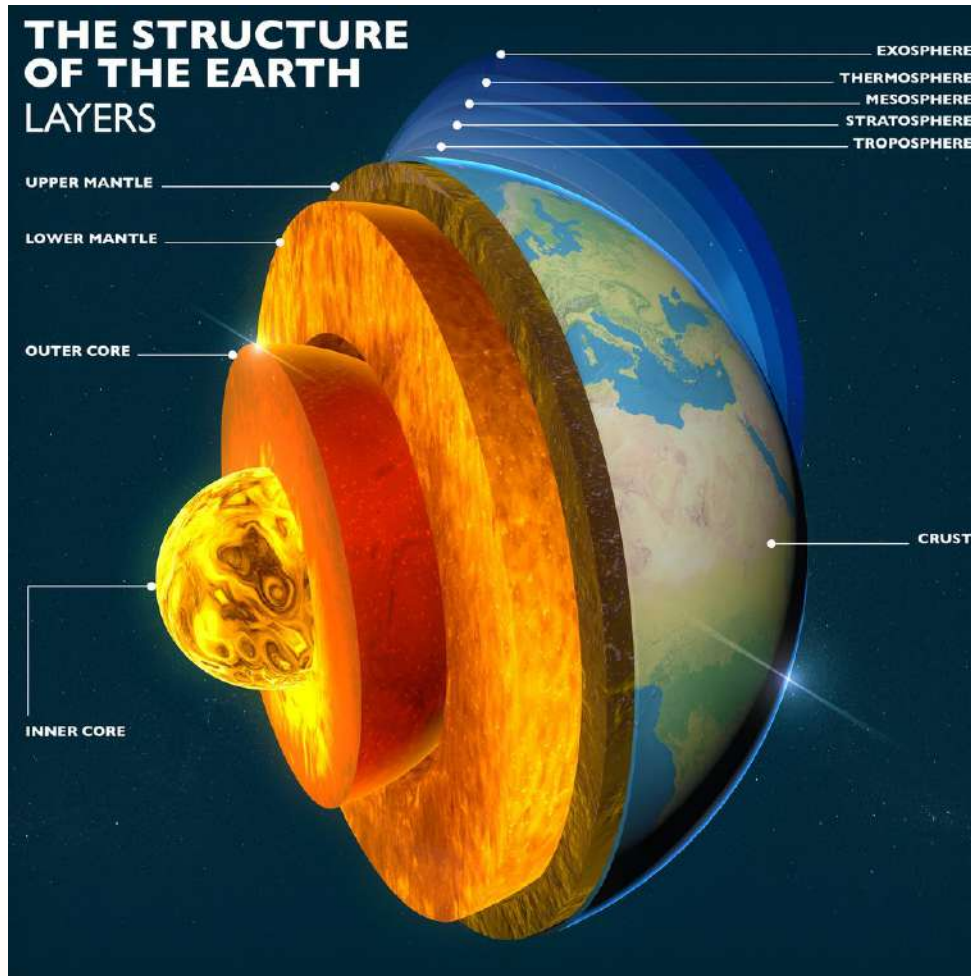
New York, USA



Kolkata, India



Energy and Environment



General Overview

- **Energy** is a prime mover of economic growth and is vital to sustain the economy. Energy consumption is an indicator of economic growth of a nation. Future economic growth depends upon the long term availability of the energy resources which are **affordable**, **accessible** and **environment friendly**. Industrialization contributes to the growth of the economy and requires energy. Consumption of energy and industrialization go together. If the economy has to grow then energy consumption also has to grow. The growth of economy depends upon the growth of infrastructure, and the infrastructure demands the consumption of energy.



General Overview

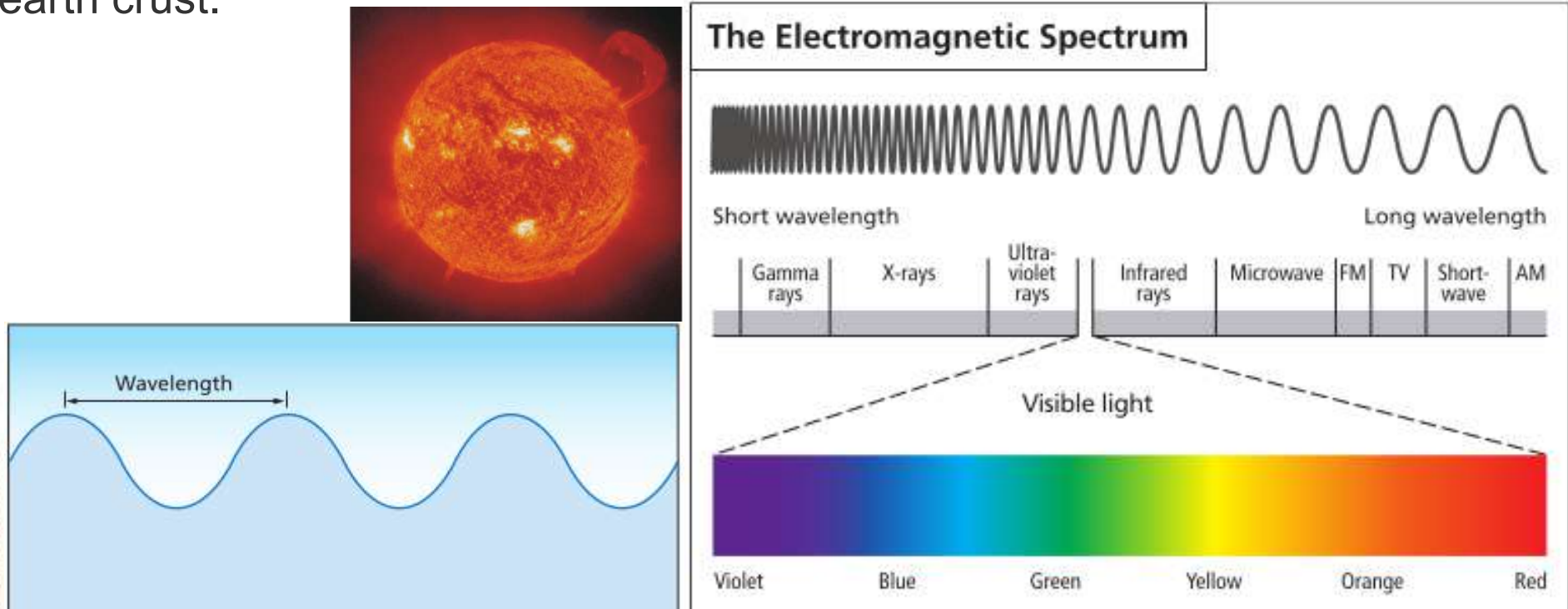
- Major energy intensive industries in 2005 required energy ~ **68%** of the total energy consumption, e.g., sectors that produced chemicals (Cement & others) took ~ **29%** of the total energy, Iron/Steel sector consumed ~ **20%** of the total energy. Steel and Cement are two main infrastructure materials. Non-metallic minerals have consumed ~ **10%** of the total energy, Paper/Pulp ~ **6%** of the total energy and Nonferrous metal ~ **3%** energy.

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General Overview

- In this perspective, we list what are the energy resources available because “*the long term sustenance of the economy will depend upon the availability of the energy resources which are affordable, accessible and environment friendly*”. Ultimate energy resource is the **Sun**. It is the **solar power** that gives energy to life. Part of this energy is stored below the earth crust and part is available above the earth crust.



General Overview

- In this perspective, we list what are the energy resources available because “*the long term sustenance of the economy will depend upon the availability of the energy resources which are affordable, accessible and environment friendly*”. Ultimate energy resource is the **Sun**. It is the **solar power** that gives energy to life. Part of this energy is stored below the earth crust and part is available above the earth crust. As such, energy resources are divided in two parts, (a) **Primary energy resources** (Natural), (b) **Secondary energy resources** (Synthetically manufactured as demand from the industry). We first take the Primary energy resources, that can be further subdivided into the following,
 - (i) **Non-renewable** energy resources.
 - (ii) **Renewable** energy resources.

General Overview

- **Non-renewable** means it takes several millions of years to form such resource. “Radiometric dating” shows that Earth formed over 4 billion years ago. In this perspective, we have non-renewable and renewable – the renewable resources are available to us all the time. Example of non-renewable energy resources are *fossil fuels* and renewable energy resources are generated from natural resources.
- **Renewable** means they are constantly recyclable, they never exhaust as long as the solar power is. But non-renewable resources takes several millions of years to form below the earth-crust, that is in this time scale the fossil fuels are termed as non-renewable energy vis-a-vis renewable energy resources.





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- **Fossil fuels** are in fact "*plant origin*". And among these fossil fuels, one have three different types of fuel, (a) Coal, (b) Petroleum, (c) Natural gas. Among the renewable energy resources, the most important one is (i) **Solar power**, (ii) **Geothermal**, (iii) **Wind**, (iv) **Biomass**, (v) **Hydrothermal**. Let's see how these non-renewable energy resources of plant origin are formed. There are special type of plants that give petroleum, natural gas and coal. **Coalification** or coal formation consist of two stages. First stage is the *Biochemical stage*. In this stage, the plant materials decay under the Earth crust, and they are degraded by the bacteria under moist condition. After this, there are several earth movement below the earth crust - there are several ecological forces also acting under the Earth crust to the deposit, which has been there at a particular time. It gets further buried into/below the earth crust and as a result of temperature and pressure, the process of coal formation begins.





- The second stage is called **Metamorphism** or *dynamochemical stage*. In this stage, there is an effect of pressure because of the depth. Because of the movement of the earth crust, the deposit which has been occurred earlier gets buried further and as a result of this the effect of pressure begins as one go down the depth. Also, there is a **tectonic pressure** which is caused by the movement of the Earth and as a result, the deposit gets buried into some type of rocks below the Earth crust. Then there comes the **effect of temperature** because there is a rise of 3-5°C for every 100 meter increase in depth. This is the most important stage in the formation of the coal deposit. And there is an effect of temperature and very high pressure and on account of it, several physico-chemical reactions take place during the life of the formation of the coal. So certain chemical reaction occur at dynamochemical stage.





- They are, for example, **dehydration** (removal of water), **decarboxylation** and **dehydrogenation**, and, on account of these three chemical reactions which are occurring because of the very large increase in pressure and temperature, and these results in removal of H_2O , CO_2 , CH_4 and H_2S . So on account of these physico-chemical reactions or dynamochemical reactions, the formation of coal occurs. The coal consists of **organic mass** (because it is from plant origin), and, this organic mass is a complex mixture of organic compounds of C, H, N, S and O. Then also coal contains **inorganic** substances like water and mineral. So as a result of these physico-chemical reactions which are a function of the pressure and temperature, the coal formation occurs at several stages.





- **Stages of coal formation** → *Wood* followed by *Peat*. This is in the increasing order of the life of formation – meaning, if one stops at Wood, Peat is obtained. Then with further depth, one obtain *Lignite* followed by *Bituminous*, which is followed by *Anthracite* and then ultimately goes to *Graphite*. So as a result of the physico-chemical changes physical change is reflected in colour, strength, density and structure. To a user the chemical changes are important, for example, O_2 content on *DryAshFreeBasis* (**DAF**) decreases from **40%** for Wood to **30%** for Peat and **20%** for Lignite, **5%** for Bituminous coal and **2%** for Anthracite. So the progressive action of the pressure and temperature brings the O_2 down the value to **2%**. As a result of this the **volatile matter** (**VM**) decreases from ~ 70% for Wood to < 5% for Anthracite. So decrease in VM and O_2 content increases the available carbon from about **30%** for Wood/Peat to almost **100%** for Anthracite. Based on the extent of Coalification, **Lignite is higher in rank than Peat and Anthracite is higher in rank than Bituminous coal.**



General Overview

- **Petroleum** is formed under the Earth crust by special type of plants which are **gelatinous** in nature. Near sea coast, such type of plants are present and with the same process as coal buried under the earth crust and over the time period of millions of years, the deposits of petroleum are formed below the earth crust. Liquid fuel oil, is derived from Crude petroleum and, is not a natural resource - it is obtained from Petroleum. Petroleum is a natural resource and it comes from – in greek *Petra* means rock and *oleum* means oil, so after drilling the rock beneath, petroleum is available for usage. Petroleum also contain elements e.g. C, H, N, O, S. From Crude Petroleum several types of bi-products are obtained, e.g. Gasolin, Lubricating oil, Fuel Oil and so on.
- These are the non-renewable energy resources along with natural gas.

General Overview

- Among *renewable* energy resources, one is *Geothermal* that is, energy obtained by trapping the heat of Earth below its surface - *hot underground water* or *steam* is used to produce electricity because solar power is partly absorbed by the Earth to produce hot water.



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- Another important source is the *Biomass* energy and it consists of *Biogas*, that is produced from current waste streams like *paper* and sugar production, animal waste and so on, and CH_4 is the main product. Also there are *biofuel* like biodiesel, ethanol which are derived from plants. We also have solid Biomass - woodfuel, biogenic portion of municipal waste and certain plants.



General Overview

- *Hydrothermal* is water in the form of kinetic energy, temperature difference and as such we have say hydrothermal powerstations for the conversion of kinetic energy of the water into the electrical energy.



Maithan Dam

$6 \times 10^4 \text{ kW}$ electric power

General Overview

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- **Solar** energy or energy collected from sunlight. It can be used in many ways - for example - generation of electricity, photovoltaic cells (but with very low efficiency factor), generation of electricity using concentric solar power.



Asutosh College
20 kW solar power

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- Another source of energy is *windpower*. Whenever windpower is available, it can be used for production of electricity.



Muppandal , TN

15000 MW wind power

Indian Context

- Lets try to realize in India, as our nation is 6th in World in terms of total energy consumption and needs to accelerate the development of its energy sectors in order to sustain 8-9% of growth in the country – as *energy*, *infrastructure*, and *growth* are interrelated. India, though rich in coal and abundantly endowed with the renewable energy, it has a very small hydrocarbon resource (fossil fuel) of the order of 4% of the total World resource. India is a net importer of energy, more than 25% of the primary energy needs been met through the import of the *Crude Oil* and *Natural Gas*. This is important when we relate our economic growth with the energy, as we are also based on the import of the energy resources. This brings us to the *energy production sector* - coal and oil account for 54% and 34% respectively, and natural gas around 6%.

Indian Context

- India's total energy production is contributed by *fossil fuel*, to the extent of **90%**, now rest say *hydrothermal* is around **6%**, *nuclear* is around **1%** & rest being *geothermal, windpower* and so on ...
- India is a large consumer of the fossil fuel energy resources - not only India but the World, around **80-90%** of the energy is being produced by primary energy resources such as coal, oil and natural gas. Industrial sector in India consumes around **5.2%** of energy. When we relate energy with the economy, then it is also has a relation with the standard of living. And standard of living can be measured in terms of energy consumption per person.

Indian Context

- Consumption of primary energy in India is **530kg** of oil equivalent per person as in 2004 compared to **1240kg** oil equivalent per person in China and World average of **1770kg** of oil equivalent per person. So growth in economy is highly related with the energy consumption and so in terms of energy consumption, *we are at least 3-4 times lower than the World average.* If the primary energy consumption per person is an indicator of the economic growth, then it has to grow, because economy is a Country's index of prosperity. When this is the scenario, that **90%** of the derived energy is from the *fossil fuels*, we are also convinced that the economy has to grow as the country has to prosper, and then, energy consumption must increase. The question is how that can be met?