CE 213A
Introduction to Environmental Science

L 5 : Unit 1
Conventional Energy Sources

Dr. Anubha Goel

FB 319, anubha@iitk.ac.in, x 7027

Schedule : LEC Mon Wed Fri 5: - 6pm

Previous lecture

- History of energy usage
- Natural resources
  - Renewable, Non-Renewable
- Energy sources, production and consumption
- Energy production and consumption

Today

- Primary sources of energy (Fossil fuels)
  - Types, problems associated with usage
  - Advantages, disadvantages
- Sulfur in coal and associated problems, feect on ecosystem
- Natural resources and associated problems
- tragedy of the commons
- Sustainable development for Resource Preservation
- SDGs, Environmental Ethics

PRIMARY (NON-RENEWABLE) SOURCES OF ENERGY - FOSSIL FUELS

TYPES OF FOSSIL FUELS

1. Liquid Hydrocarbons- Petroleum (oil)
2. Coal
3. Natural Gas

Photo credit: California Energy Commission

How is energy lost?

About ½ of all primary energy is lost when converted to more useful forms

- **Coal**
  - 66% is lost to thermal conversion when energy in coal is converted to electricity.
  - 10% is lost when transmitted to you at home.
- **Oil**
  - 75% lost during distillation, transportation, storage, combustion in vehicles
- **Natural Gas**
  - 10% lost in shipping & processing
  - Most efficient and least polluting

    has more H than C so produces less CO_2 when burned so contributes less to global warming.)

Concept of Calorific value

CALORIFIC VALUE

- There are different expression for calorific value-

1- Gross calorific value (GCV)-: The quantity of heat evolved by the combustion of unit quantity of fuel is its gross calorific value. In Gross calorific value the final product of combustion being at reference temperature of 25° C and **water obtained in the liquid state**.

2- Net calorific value (NCV)-: Net calorific value is the quantity of heat evolved when a unit quantity of fuel is burnt **in oxygen**, the original material and the final products of combustion being at a reference temperature of 25° C and the **water obtained from the fuel being at the vapor state**.

- Hence NCV is always less than GCV by the amount corresponding to the heat of condensation of water vapors i.e. 587 kcal/kg

So NCV = HCV – Latent heat of water vapor formed

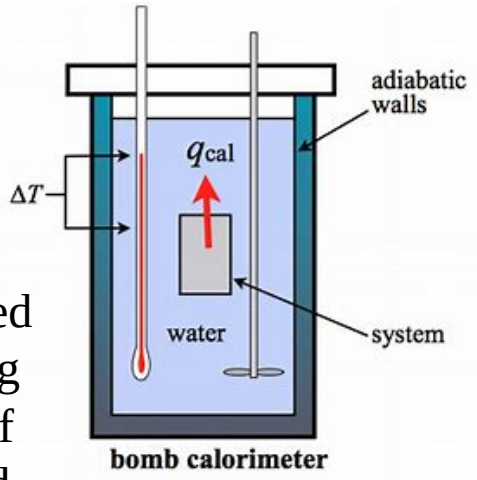
= HCV – Mass of hydrogen x a x Latent heat of steam

Since 1 part by mass of hydrogen produces ‘a’ part by mass of water

Units of calorific value-: The calorific value is expressed in either calorie/gm (cal/gm) or kilocalorie/kg (kcal/kg)

CALORIFIC VALUE

- It is determined by BOMB CALORIMETER



A bomb calorimeter is a type of constant-volume calorimeter used in measuring the heat of combustion of a particular reaction. Bomb calorimeters have to withstand the large pressure within the calorimeter as the reaction is being measured. Electrical energy is used to ignite the fuel; as the fuel is burning, it will heat up the surrounding air, which expands and escapes through a tube that leads the air out of the A bomb calorimeter is a type of constant-volume calorimeter used in measuring the heat of combustion of a particular reaction. Bomb calorimeters have to withstand the large pressure within the calorimeter as the reaction is being measured.

Electrical energy is used to ignite the fuel; as the fuel is burning, it will heat up the surrounding air, which expands and escapes through a tube that leads the air out of the calorimeter. When the air is escaping through the copper tube it will also heat up the water outside the tube. The temperature of the water allows for calculating calorie content of the fuel calorimeter. When the air is escaping through the copper tube it will also heat up the water outside the tube. The temperature of the water allows for calculating calorie content of the fuel

DETERMINATION OF CALORIFIC VALUE

- It is determined by BOMB CALORIMETER by the following formula-

$$L = GCV = (W+w)\,(t_2 - t_1)/m \text{ cal/gm}$$

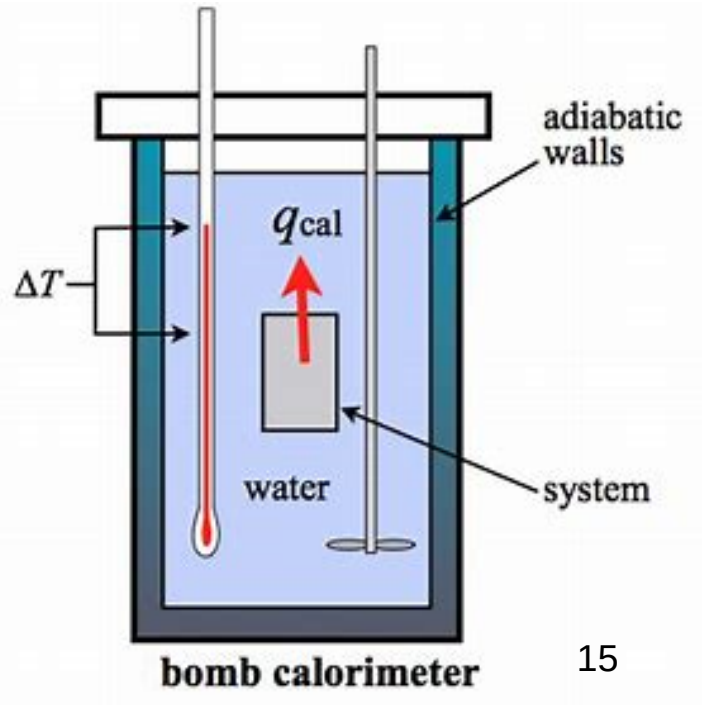
Where m = mass of fuel pellet (g)

W = mass of water in the calorimeter (g)

w = water equivalent of calorimeter (g)

t_1 = initial temperature of calorimeter

t_2 = final temperature of calorimeter



Question-: Calculate the gross and net calorific value of a coal sample having the following composition C= 80% , H= 5% , O = 4%, N = 3%, S = 3.5 % and ash = 5%

Solution-: Apply Dulong's formula

$$GCV = 1/100[8080C + 34500(H - O/8) + 22400\ S\ ]$$

And $NCV = (GCV - 0.09H \times 587)$

So, GCV = 8094.9 cal/g

And NCV = 7830.75 cal/g

Some conversion factors

- One calories is the amount of energy needed to raise temperature of 1g of water by 1°C at 1 atm
- A kilocalorie is 1,000 calories
- 1 BTU = energy to heat 1 lb of water 1°F
- 1 watt (W) = 3.412 Btu/hour
- 1 horsepower (hp) = 746 W
- Watt-hour- used to describe electrical energy. Usually use kilowatt-hour (kWh)/ it is larger.

Problems with Fossil Fuels

- **Non-renewable**
  - At projected consumption rates, natural gas & petroleum will be depleted by the end of the 21st century

- **Impurities are major source of pollution**
  - **SO_2** travels on air currents & falls with precipitation as **acid rain**
  - **Mercury bio-accumulates & biomagnifies** thru ecosystems when it travels on air currents and fall as **particulate dust or with precipitation** elsewhere.

- Burning fossil fuels produces large amounts of CO_2, which contributes to **global warming**

- Makes us rely on other countries for our energy needs. Makes us vulnerable.

1. OIL

- Liquid mixture of hydrocarbons with S, O, N impurities
  - Impurities can create SO_2 and NO_x air pollution
- Formed from remains of plankton, plants, animals in shallow seas millions of years ago.
- May be pumped up or may be under pressure
- Important producers: OPEC, Alaska, Siberia, Mexico

Good news!

Indian Government approves 2 more strategic oil reserves

Read more at:
http://timesofindia.indiatimes.com/articleshow/64765667.cms?utm_source=contentofinterest&utm_medium=text&utm_campaign=cppst

Indian Government nod for adding 6.5 MMT oil reserves

https://www.thehindu.com/business/Industry/govt-nod-for-adding-65-mmt-oil-reserves/article24273287.ece

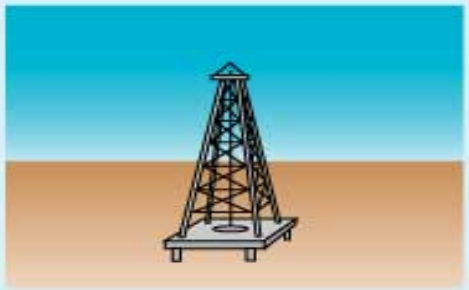
Advantages

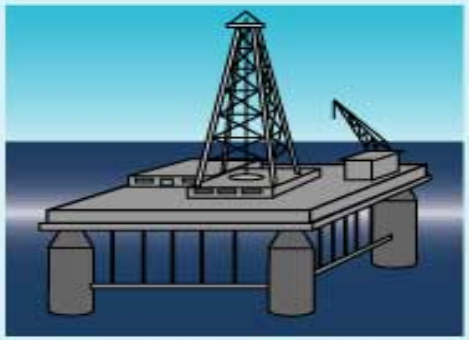
Ample supply for 35–84 years

Low cost (with huge subsidies)

High net energy yield

Easily transported within and between countries





Disadvantages

Need to find substitute within 50 years

Artificially low price encourages waste and discourages search for alternatives

Air pollution when burned

Releases CO_2 when burned

Moderate water pollution

2. NATURAL GAS

- Mixture
  - 50–90% Methane (CH_4)
  - Ethane (C_2H_6)
  - Propane (C_3H_8)
  - Butane (C_4H_{10})
  - Hydrogen sulfide (H_2S)

LPG

- When a natural gas field is tapped, **propane and butane** are liquefied and removed as liquefied petroleum gas (**LPG**)
- The rest of the gas (mostly methane) is dried, cleaned, and pumped into pressurized pipelines for distribution
- Liquefied natural gas (**LNG**) can be shipped in refrigerated tanker ships

Advantages

Ample supplies (125–200 years)

High net energy yield

Low cost (with huge subsidies)

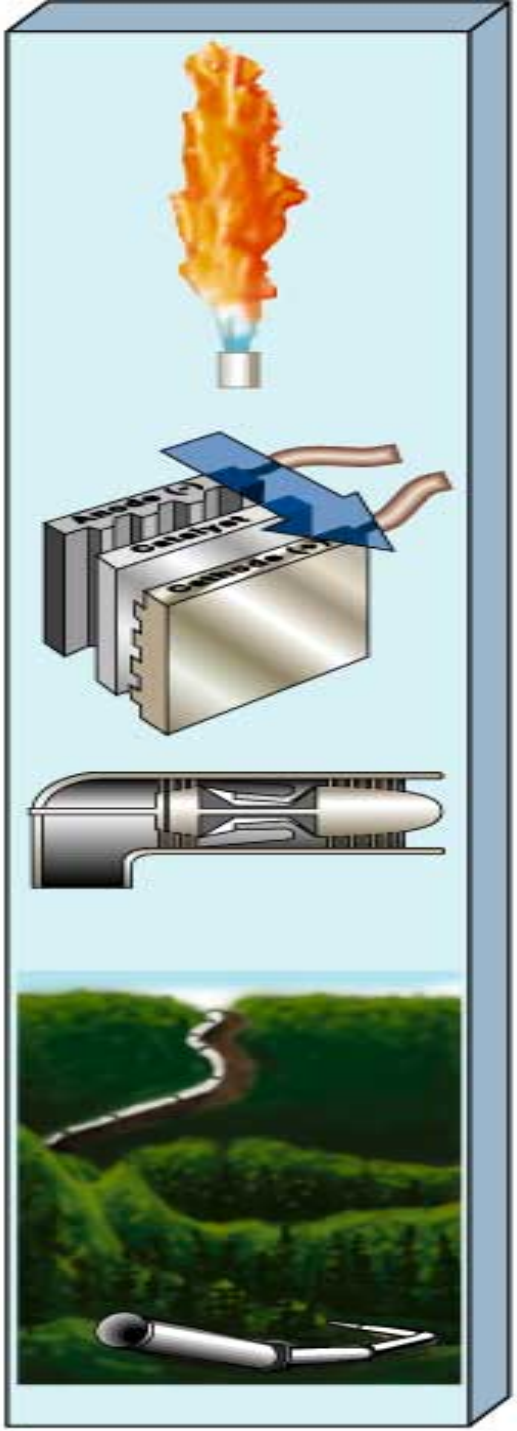
Less air pollution than other fossil fuels

Lower CO_2 emissions than other fossil fuels

Moderate environmental impact

Easily transported by pipeline

Good fuel for fuel cells and gas turbines



Disadvantages

Releases CO_2 when burned

Leaks of methane (a greenhouse gas)

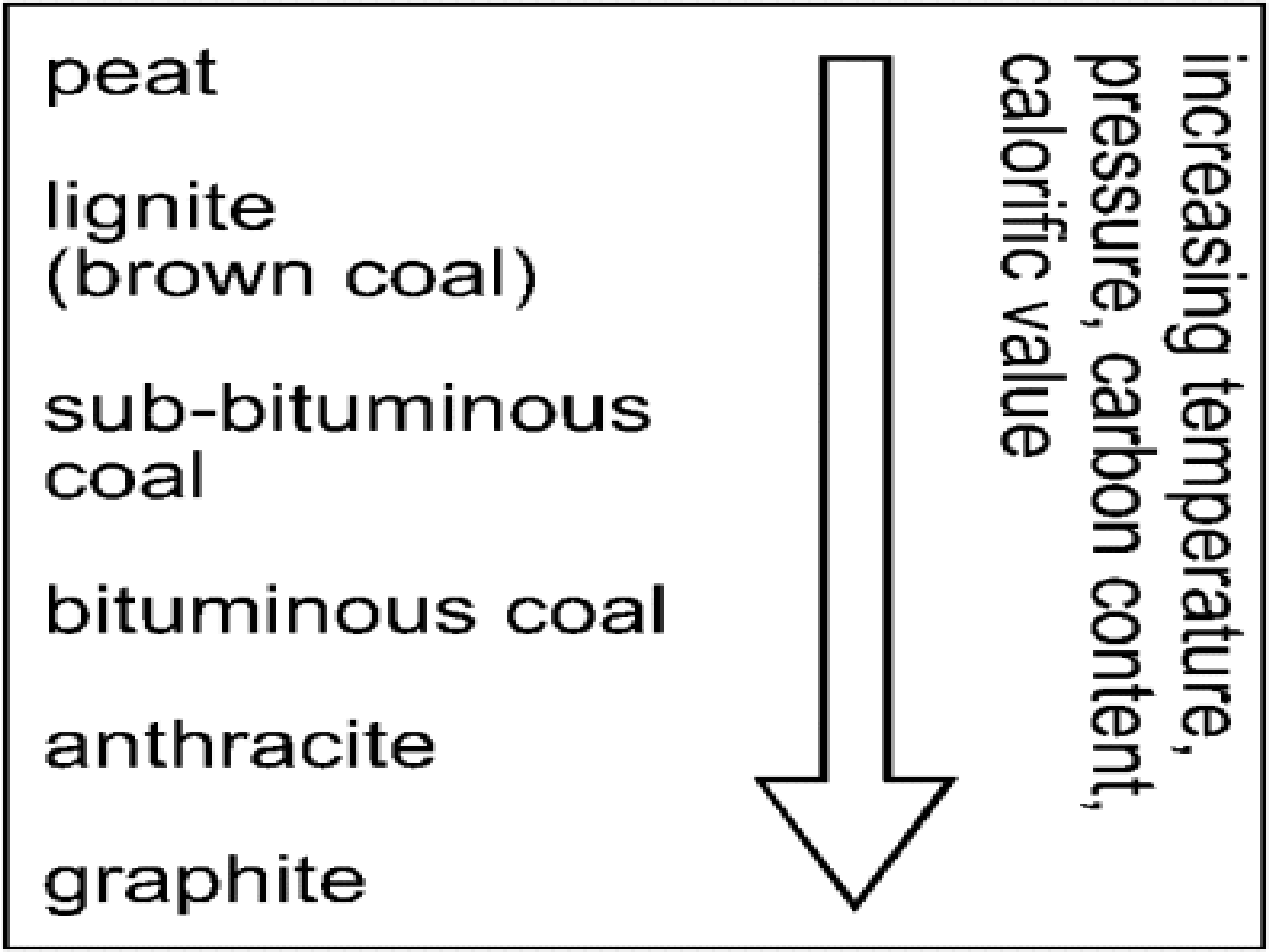
Shipped across ocean as highly explosive LNG

Sometimes burned off and wasted at wells because of low price

3. Coal

- Coal is primarily made of Carbon, Hydrogen, Oxygen, Nitrogen, Sulphur and varying quantities of aluminium, zirconium and many other minerals.
- Coal exists in many forms therefore a chemical formula cannot be written for it.
- Coalification: After plants died they underwent chemical decay to form a product known as **peat**
  - Over many years, thick peat layers formed.
  - Peat is converted to coal by geological events such as **land subsidence** which subject the peat to **great pressures and temperatures**.

Graphite is the most stable form of carbon under standard conditions.


peat
lignite
(brown coal)
sub-bituminous
coal
bituminous coal
anthracite
graphite
increasing temperature,
pressure, carbon content,
calorific value

In terms of increasing carbon content, hardness, heat content and decreasing moisture **coal is of three types** viz. Lignite, Bituminous and Anthracite. Further, Peat, first step in formation of coal. Peat is not coal but is the is wood that has undergone some transformation towards coal formation and the material contains a large amount of moisture and the carbon content is very low.

Characteristic	**Peat**	**Lignite**	**Bituminous**	**Anthracite**
Colour	Dark-brown	Blackish Brown	Black	Greyish Black
Lustre	No lustre	No lustre	Some lustre	Metallic lustre
Appearance	Earthy / woody appearance with dead, original plant material	Less woody in ppearance	Striped	shiny metallic appea rance
Natural moisture	Highest	High	Relatively lower	Lowest
Hardness	Softest	Softer	Soft	Hardest
Upon burning	Smoke	Smoke	Large smoke	Smokeless
Carbon Content	<40%	<40%	40-90%	>90%

Key Qualities

Advantages and Disadvantages

Pros

- Most abundant fossil fuel
- 300 yrs. at current consumption rates
- High net energy yield

Cons

- Dirtiest fuel, highest carbon dioxide
- Major environmental degradation
- Major threat to health

Alternate Uses of Coal

- Coal **gasification**
  ® Synthetic natural gas (SNG) or Syngas (made up of CO and H_2)

- Coal **liquefaction**
  ® Liquid fuels (oil) ® gasoline

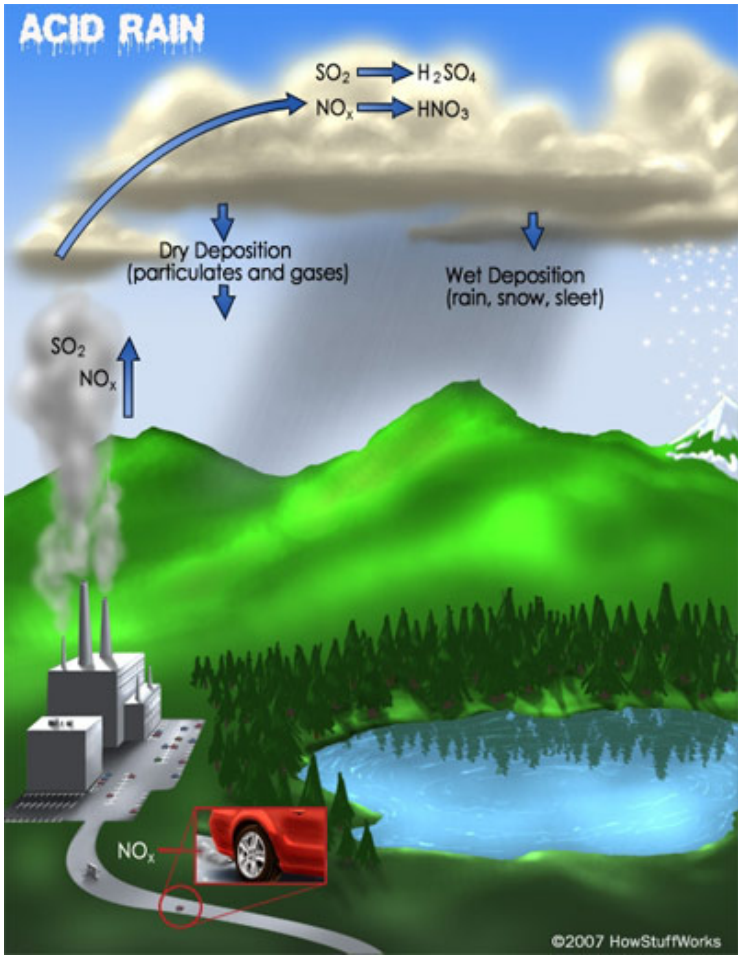
- Disadvantage
  – Costly
  – High environmental impact

Sulfur in Coal

  - Two chief forms of sulfur
    - inorganic (FeS_2 or $CaSO_4$)
    - organic (Sulfur bound to Carbon)
- When coal is burned, sulfur is released primarily as sulfur dioxide (SO_2 - serious pollutant)
  - Coal Cleaning - Methods of removing sulfur from coal include cleaning, solvent refining, gasification, and liquefaction

Effects of Sulfur Pollution

- Sulfur combines with water in atmosphere to create **sulfuric acid- <u>acid rain</u>**
- Falls as fine particulate pollution- **<u>dry deposition</u>**
- Increased sulfur oxide aerosols **absorb incoming** UV radiation thereby **<u>cooling the atmosphere</u>**
- Sulfur oxide aerosols can irritate mucous membrane linings in <u>respiratory system</u>



Effects on Ecosystems of acid rain from sulfur dioxide.

- Acid rain leaches metals (Al) out of soil, settles on fish gills, causing suffocation.
- Leaches out soil nutrients
- Kills eggs, larvae, fry (baby fish), and some adult fish
- Changes in pH can make some chemicals more toxic- kills trees or aquatic life
- Decreases health of plants- more susceptible to disease
- As animals die from pH changes, other more hardy animals will fill those new niches
- Upsets food web when sensitive species die.
- If regional climate changes due to cooling from sulfur pollution
  - Changes in crops
  - Changes in vegetation which leads to changes in fauna distribution
  - Changes in precipitation patterns

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L 6 : Unit 1
Tragedy of the Commons and Envtl. Ethics

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QUESTIONS

- Predicted energy requirements globally and for India
- How long will the ‘traditional’ sources provide for world energy demand
- What are alternate sources of energy other than oil, fossil fuel, natural gas
- How India plans to meet its energy demands with depletion of ‘traditional’ sources of energy
- How is energy used in India
- What are the major sources of energy in India
- What steps are being taken by GOI to meet these demands
- Which sector of alternate energy is being promoted in the country and how

India is set for a period of rapid, sustained growth in energy demand

Answer

World Energy Outlook 2018 - Executive Summary - IEA

(source: International Energy Agency www.eia.gov)

Highlights for India from the latest World Energy Outlook

1. India is the largest contributor to global demand growth between 2016 and 2040, amounting to almost 30%.
2. Oil demand in India increases by more than 4 times by 2040.

(details in Handout 2 posted online)

Tragedy of the Commons

- Depletion or degradation of a potentially renewable resource to which people have free and unmanaged access.
- An example is the depletion of commercially desirable fish species in the open ocean beyond areas controlled by coastal countries.

Real life situations

- A small village consists mostly of farmers that raise and sell sheep at a nearby city. The only place for the sheep to graze is a commons in the center of the village.
  - A commons is an area that belongs to no individual; it is shared by the entire society.
- The villagers in this situation will have an incentive to obtain and graze as many sheep as possible, leading to overgrazing and barren lands.
- A second village has its grazing land divided into nine fenced sections, each of which is owned by a different family.
  - These families will carefully control the amount of grazing to ensure their land is usable in the long-term.

Sheep grazing, Hawf Protected Area, Yemen.
Picture by Sebastian Kennerknecht

Tragedy of the Commons

- An ecologist named Garrett Hardin wrote an essay called "*The Tragedy of the Commons*", describing a major source of environmental conflict: **resources that are not privately owned or regulated will often be depl**eted.
  - The self-interest of individuals takes priority over the best interests of the entire population.

- Climate change, air pollution, water pollution, and overfishing of international waters are all modern examples of the Tragedy of the Commons.
- How can we avoid this ?

Norilsk, Russia
Source: ecojunk.wordpress.com

Zadar, Croatia
Source: Agence France-Presse

Need for Sustainable development for resource preservation

- Unsustainable utilization can result from overuse of resources, because of population increase, and because many of us are using more resources than we really need.
- Most of us indulge in wasteful behaviour patterns without ever thinking about their environmental impacts.

Sustainable Development Goals (SDGs)

In 2015, world leaders gathered at the UN to adopt 17 Sustainable Development Goals to achieve several extraordinary things by 2030: end poverty, promote prosperity and well-being for all, and protect the planet. The Sustainable Development Goals set a course to achieve these objectives – for people everywhere.
The year 2016 marked the first year of the implementation of the SDGs.

The 17 sustainable development goals (SDGs) to transform our world:

- GOAL 1: No Poverty
- GOAL 2: Zero Hunger
- GOAL 3: Good Health and Well-being
- GOAL 4: Quality Education
- GOAL 5: Gender Equality
- ***GOAL 6: Clean Water and Sanitation***
- ***GOAL 7: Affordable and Clean Energy***
- GOAL 8: Decent Work and Economic Growth
- GOAL 9: Industry, Innovation and Infrastructure
- GOAL 10: Reduced Inequality
- ***GOAL 11: Sustainable Cities and Communities***
- GOAL 12: Responsible Consumption and Production
- ***GOAL 13: Climate Action***

Environmental Ethics

- Environmental ethics is a branch of applied philosophy that studies the conceptual foundations of environmental values as well as more concrete issues surrounding societal attitudes, actions, and policies to protect and sustain biodiversity and ecological systems
- The concept of environmental ethics brings out the fact that all the life forms on Earth have the **right to live**.

Videos

- What are Environmental Ethics

https://www.youtube.com/watch?v=F_rfh9zt5WU

- Natural resources and associated problems

https://www.youtube.com/watch?v=WwfpiLFNYxs

Resources

- International Energy Agency
  - www.eia.gov
- **Ministry of Power http://powermin.nic.in/**

- **Ministry of New and Renewable Energy**
  - *www.mnre.gov.in/*

  The *Ministry* of New and Renewable *Energy* (MNRE) is the nodal *Ministry* of the Government of *India* for all matters relating to new and renewable *energy*.

- **Solar Energy Corporation of India Limited(SECI), A ...**
  - *www.seci.gov.in/*