2nd lecture

How is energy used? It is customary to divide energy usage among four sectors of economic activity: industrial (manufacturing, material production, agriculture, resource recovery), transportation (cars, trucks, trains, airplanes, pipelines and ships), commercial (services), and residential (homes).

As an example; In the United States in 1996, these categories consumed, respectively, 36%, 27%, 16%, and 21% of the total energy.

Coal is generally cheaper than oil, whereas natural gas is more expensive. The difference in price reflects the different costs of recovery, storage, and transport. Nuclear fuel refined for use in nuclear electric power plants is less expensive than fossil fuels, per unit of heating value.

The scene of energy resources have been visualized in terms of various parameters. Mainly the population increase and also the need to increase the standard of living are the factors forcing to see new and alternate energy options. The climate change which is threatening the existence of life is another factor forcing to consider alternate energy sources. However the energy sources to be adopted will have to meet the varying needs of different countries and at the same time enhance the security of each one against the energy crisis or energy shortage that have taken place in the past. The factors that need consideration for the search for new energy sources should include:

(i) The global energy situation and demand

(ii) The availability of fossil sources

(iii) The efficiency of the energy sources

(iv) The availability of renewable sources

(v) The options for nuclear fission and fusion.

*Energy from Nuclear fission though can be conceived as an alternate for the production the necessary electrical energy, the current available technologies and reactors may not be able to meet this demand. *Therefore the alternative for energy supply should include fossil fuel with carbon dioxide sequestration, nuclear energy and renewable energies. Possibly fusion and also hydrogen based energy carrier system will evolve. However, the costs involved may even force the shift to the use of coal as an energy source in countries like India and China. Table 1 comprises some pollutants including the product of fossils combustion

*There are a variety of energy resources and energy forms. These include hydro power, wind, solar, biomass and geothermal for resources and in the energy forms, light, heat, electricity, hydrogen and fuel. How this transition has to occur depends on many factors.

Table1. Effects of pollutants on human being health

Types	Effects
Primary pollutants	
CO	Heart disease, strokes, pneumonia, pulmonary tuberculosis, congestion of brain and lungs.
SO_x	Acute respiratory infection (chronic pulmonary or cardiac disorders)
NO_x	Chronic respiratory infection (chromic bronchitis, emphysema and pulmonary oedema)
HC	Lung and stomach cancer
SP	Tissue destruction of the respiratory epithelium (deleterious effects on the lining of the nose, sinus, throat and lungs) cancer
Pb and PbO_x	Brain damage, cumulative poisoning (absorbed in red blood cells and bone marrow.
Secondary pollutants	
PAN and NO_2	Attacks of acute asthma and allergic respiratory infections (chronic bronchitis and emphysema).
O_3	Chest constriction, irritation of mucous membrane, headache, coughing and exhaustion.
Aerosols	
SO_4^{2-} and NO_3^-	Asthma, infant mortality and acute respiratory infections
Others	
Aldehydes, olefins, nitroamines PAH	Respiratory tract carcinoma
Acrolein	Irritation to eyes

WHY HAS RENEWABLE ENERGY BEEN NEGLECTED UNTIL FAIRLY RECENTLY?

There are many reasons aside from simple inertia why moving away from fossil fuels and toward renewable energy has and will continue to be a challenge. First, the awareness of the environmental problems associated with fossil fuels has come very gradually, and views on the seriousness of the threat posed by climate change vary considerably. Moreover, in times of economic uncertainty long-term environmental issues can easily take a backseat to more immediate concerns, especially for homeowners.

Second, compared to fossil fuels there are problems with renewable sources, which may be very dispersed, intermittent, and expensive— although the cost differential varies widely, and often fails to take into account what economists refer to as "externalities," i.e., costs incurred by society as a whole or the environment. The intermittency poses special problems if the renewable source is used to generate electricity at large central power plants connected to the grid. One can cope with this problem using various energy storage methods, and upgrades to the electric power grid, but of course both have costs, see table 2.

Table 2. Costs of Generating Electric Power per MW Installed as of 2011, with Renewable (Green) Sources Shown Using a Bold Font

Source	$/MWh	Capacity (%)
Gas (comb cycle)	66.1	87.0
Hydro	86.4	52.0
Coal	94.8	85.0
Wind	97.0	34.0
Geothermal	101.7	92.0
Biomass	112.5	83.0
Adv nuclear	113.9	90.0
Coal with CCS	136.2	85.0
Solar PV	210.7	25.0
Wind (offshore)	243.2	34.0
Solar thermal	311.8	18.8

Example 3: Which Solar Panels Are Superior?

Suppose that ten type A solar panels produced enough power for your electricity needs, had a lifetime of 30 years, cost only $1000, but they had an efficiency of only 5%. Five type B panels cost $5000 but they had an efficiency of 10%, and lasted only 15 not 30 years. Which panels should you buy?

Solution

Obviously, the more efficient panels would take up only half the area on your roof than the type A panels, but who cares if they both met your needs. The cost over a 30 year period would be $1,000 for the type A panels, but $10,000 for the more efficient type B panels that produced the same amount of power (since they last only half as long), so clearly you would opt for the less efficient choice in this case. As a general rule, as long as the fuel is free, and there are no differences in labor or maintenance costs, your primary consideration would almost always be based on cost per unit energy generated over some fixed period of time—usually the lifetime of the longer-lived alternative.

Example 4: How the Usage of Wind Power to Offset Coal-Fired Plants Can Generate More Emissions Not Less.

Suppose that a certain fraction of the power produced by a 500 MW coal plant is offset by wind power. Assume that when the coal plant runs at its constant rated power it has an efficiency of 35%, but that when it needs to be ramped up and down to compensate for the wind power variations its efficiency is reduced by according to $e = 0.35 - 0.00001p^2$, where p is the amount of wind power. Find the percentage increase in emissions that results when 90 MW of the 500 MW is generated by wind power instead of coal.

Solution

In order to generate the full 500 MW by itself, the coal plant requires 500/0.35 = 1429 MW of heat flow from the coal. If the wind power is 90 MW the efficiency of the coal plant is reduced to $e = 0.35 - 0.00001(90)^2 = 0.269$, and the heat flow required to generate (500 − 90) = 410 MW is therefore 410/(0.269) = 1524 MW. The percentage increase in emissions is the same as the percentage increase in the heat flow to the coal plant, i.e., 6.7%.

Problem 1: Using the data in Example 4, find the amount of wind power that could be used with a 500 MW coal-fired plant that would result in the least amount of emissions