Lecture 4 Feb 1, 2012.
Environmental science FFY471, Env physics FYP350

This lecture mostly deals with energy in thermodynamical terms.

Our energy situation on the earth is that we have a lot of different energy resources like gas, coal, oil, biomass, uranium, wind power, hydroelectric power etc. In order to make the energy resources useful for human purposes it most in general be transformed or converted in some way. The man or the society use energy for heating or work. (Including negative heating equal cooling.) The conversion of crude energy resources to useful energy has environmental impact, like the combustion of gas.

The energy resources are finite and this fact together with the environmental impact in form of air pollution and climate change force us to be somewhat cautious in using and dealing with the energy resources.

Science and energy

What can we learn from science when it comes to the management of the energy resources on a global scale?
Science tells what is going on and why different things happen.
It does not tell what to do.

Energy and energy processes are studied in physics and chemistry and more specifically within thermodynamics.
There are fundamental laws, principles and concepts within thermodynamics which we will briefly touch upon.

The first and second law of thermodynamics are respectively
- energy is conserved. Energy can not be destroyed or generated.
- the entropy change is zero or increase in any reaction or process.

In order to try to make the thermodynamical business less abstract we will consider a concrete case: one litre of oil.

Assume we have one litre of oil in a small container.
The oil has some stored chemical energy, U_{chem}
This energy is old solar energy, built up through hundred of millions of years.
How can we release that energy?
One way is by oxidation, that means combustion. The oil burst into flames when oxygen is delivered at high temperature.
After the combustion the oil is in a gaseous state. What is the energy content of this gas?
It is quite close to U_{chem}.
This gaseous energy $U_{gas} \approx U_{chem}$ is as thermal or internal energy in the gas and we name it Q.
How can we extract useful energy from Q?
The "oil gas" is at a high temperature and high pressure. The conversion from high temperature - high pressure oil-gas energy to energy we use can be done in very many different ways. Through different thermodynamical processes.
It is now time to ask what we are going to use the energy to.
It can be used for work or heat. Let us assume we want to have work, i.e run a vehicle.

The oil-gas can then be combusted in an ordinary internal-combustion engine (IEC), by a so called Otto process. The Otto process is a cycle with two isochoric and two adiabatic processes.
The work W released in that process is considerably less then Q. The work divided by the delivered energy Q is the efficiency η of the engine, η=W/Q. In practise the η-value for an ordinary gas car is about 0,3. In theory it can be quite higher.

The most efficient combustion process is the Carnot process. However this process is not feasible from a technical point of view.
The Q-energy can be considered as heat energy and heat energy can not be completely transformed to work. The loss of energy in the transformation process depends on the temperature and pressure of the gas both before and after the combustion process.

The maximum available work in the system with energy Q is called (sometimes) the exergy of the system. The exergy is consumed in the transformation whereas the energy never can be "consumed" in literal meaning.

The maximum available work in a gas at temperature T_H in an atmosphere (or final state) at temperature T_o is
$B = Q(1-T_o/T_H)$.
This B-energy can be converted to work if ni entropy is produced during the process, a reversible process. If entropy is produce, which in reality is always the case, the work extracted will be less than B.

From thermodynamics we can learn how well a device can deliver work. And we can learn or calculate that, with reasonable accuracy, in any arbitrary process.

What we have found out is that it is not possible to completely convert heat to work. From heat to heat we can go with 100% maintenance of the energy.
One should then believe it is best to use the oil for heating.
However that is not evidently. The "oil-gas" at high temperature can be used for heating, but if we do, we lose some high quality energy.

Heat at a high temperature has a higher quality than heat at a lower temperature. That the quality is higher means that a larger fraction of the energy content can be converted to work. So a proper action can be to use the one litre of oil to produce electricity (work) for an heat pump and let this heat pump be used for home heating. The heat wasted in the electricity generation can than also be used for heating.

We can go on with discussions of thermodynamic processes or energy conversion processes, but we conclude by saying that thermodynamics, and science as physics and chemistry, are good in describing processes and put limits on the possibilities. However they do not tell how to arrange the energy systems in the society and which energy resources to use.

Chapter 15 in the textbook on Energy

Brief summary of what was said on the lecture and what is in the chapter.

What major sources of energy to we use world-wide?
About 75-80% fossil fuel (coal, gas, oil), 6 % nuclear power and 18% renewable resources.

These fractions of fossil fuel, nuclear energy and renewables have not changed very much during later decades. There is an increase of renewable energy production, but it is also a total increase of energy production, by fossil fuels.

How should energy resources be evaluated?

- on the basis of their supplies
- the environmental impact of using them
- how much useful energy they produce

The last point has to do with the loss of energy in the way between the raw material and the use of the energy. That leads to the introduction of the concept of net energy. The net energy is the total amount of useful energy available from an energy resource minus the energy needed to find, extract, process and get that energy to the consumers.

Then study in particular the figures with disadvantages and advantages of the different energy resources.
Some of these disadvantages and advantages are of a specific national (US) character. Don't focus too much on these national characteristics.

Wait with the section on Nuclear energy until later in the course.