ET3034Tux - 1.2.1 – Energy Conversion 1

Let's start with the first question. What is energy?

I notice that when I ask this question to students, they usually have trouble giving an exact definition.

And I must say it is not easy.

The scientific definition for energy would be something like: the capacity of a system to perform work.

We humans use energy to do some work.

We use energy for heating air and water.

We use energy for transportation of people and products by cars, trains, trucks and planes.

We use energy to produce food and products.

We use energy to illuminate houses and streets.

We use energy to watch TV, do our laundry, working on computers and surfing the internet.

At the moment you are consuming energy by watching this video lecture.

Energy appears in many forms in our daily life, like gravitational energy, kinetic or mechanical energy, electrical energy, heat radiation, wave energy, chemical energy and nuclear energy.

The total amount of energy is always conserved.

The form of energy may change in time, but the total amount does not change.

This means that if we want energy to work for us, we usually convert it from one form to another form.

An example is the electric motor, this is a tool in which we convert electrical energy into mechanical energy.

The unit of energy is joule (J).

Power is the energy per time and is expressed in watts (W).

1 watt is 1 joule per second.

In this course we will use a more practical unit, which is generally used to express the electrical energy, kilowatthours (kWh).

1 kWh equals the energy of a power of 1 kW being used for 1 hour.

1 kWh equals 3.6 million joules.

The world as we know today is based on the capability of humans to convert energy from one form to another form.

The most prosperous and technologically developed nations are also the ones which have access to and are using the most energy per capita.

Therefore, many people believe that the biggest challenge for human kind in this century is tackling the energy problem.

Why do we have a problem?

The first challenge the human kind is facing is a supply-demand problem.

The demand is constantly growing.

The world population is still rapidly growing, and some studies predict a world population of 9 billion around 2040 in reference to the 7 billion people living on this planet today.

All these people will need energy, which increases the global energy demand.

In addition, the energy consumption per capita is linked to the living standard of a country.

In 2010, in the United States (US) around 230 kWh of energy per capita per day was used, whereas countries in Africa, like Nigeria, only used one tenth of this energy, around 23 kWh per day per capita.

In this graph you see the living standard expressed in human development index.

The darker the color, the more developed the regions are.

However, the light colors in this figure are getting darker by the year.

In many countries the living standard is rapidly increasing like China and India, where approximately 2.5 billion people are living.

These people represent more than a third of the world's population.

Both increasing world population and increasing living standards will increase the energy demand.

The International Energy Outlook 2013 predicts that the energy consumption will increase by 56% by 2040 in reference to 2010.

The increasing demand in energy has economic impact, as well.

If there is more demand for a product, while supply does not change much, the product will get more expensive.

This is also true for energy.

As an example we show a plot of the annual averaged price for an oil barrel, normalized to the value of the 2008 US dollar.

First, you can see that prices went up during the oil crisis in the 70s.

In this decade some countries stopped producing and trading oil for a while.

The second era of higher oil prices started at the beginning of this millennium.

Due to the increasing demand from new growing economies, the oil prices have been significantly increased.

A second challenge that human kind is facing is related to the fact that our energy infrastructure heavily depends on fossil fuels like oil, coal and gas.

Fossil fuels are nothing but millions and millions of years of solar energy stored in the form of chemical energy.

The problem is that humans deplete these fossil fuels faster than they are generated through the photosynthetic process in nature.

Therefore, fossil fuels are not a sustainable energy source.

In the coming century we will see that we are running out of the oil and gas reserves if we continue our current rates of consumption.

Another barrier is that it is technological more challenging to get the fossil fuels out of the reserves currently left.

Governments and companies are willing to take higher risks, like we have seen in the Gulf of Mexico spill in 2010.

A third challenge is that by burning fossil fuels we produce the so-called greenhouse gases (GHG) like carbon dioxide.

The additional carbon dioxide created by human activities is stored in our oceans and atmosphere.

Here you see the increase in carbon dioxide concentration in the Earth's atmosphere up to 2000.

Most scientists think the increase in carbon dioxide is responsible for the global warming and climate change, which can have drastic consequences of the habitats of many people.

Therefore, human kind is looking for alternative energy sources, like solar and wind.