Chapter 1 Introduction

1.1 Energy – a global problem

All the human activities imply energy consumption from many sources. A lot of economic and social factors as economic development, scientific and technological progress, the world population growing determine a permanent increasing energy demand.

The actual energy consumption relies mostly on fossil fuels, which are not renewable and non-uniform situated in the earth crust. The energy supplying for all countries can be provided only by the international trade using different method for transport.

These features are accompanied by large quantities of wastes resulted from the fossil fuel burning, which have negative consequences on the environment: atmosphere, water and soil. The pollution of the atmosphere covers the entire planet; the other two zones are mostly locally affected.

A conclusion is that the energy problems have a global impact and must be improved at a global scale, too.

For the energy domain, the main arguments which underline the systemic character of the interdependencies are:

- For all the world people, the unique energy provider is the environment.
- The energy resources are non-uniform distributed on the earth and the quantities are limited.
- Because the most utilized resources are located inside the borders of independent countries, there exists a contradiction between the right of the owner to the national resources and the aspirations of others for access to the same resources.
- The fossil fuels consumption has negative environmental consequences, which affect all the world population.

As consequence of these issues and many others, the energy frameworks and relations are significant components of the economical and political international order.

All the governments as well as some important world organizations have proposed energy strategies for the next decades. One of them, the World Energy Council (WEC), issued in 2000 a statement which, among other things, delineated the key energy policy actions for the period up to year 2020. These actions must be relied on three principles, named the 3A:

Accessibility to modern energy means that energy must be available at prices which are both affordable (low enough for the poorest people) and sustainable (prices which reflect the real costs of energy production, transmission and distribution to support the financial ability of companies to maintain and develop their energy services).

Availability relates to long-term continuity of energy supply as well as to short term quality of service, because energy or an electricity shortage can also to be disruptive for economic development. This implies that the "right energy mix" relies on a well diversified portfolio of domestic or imported or regionally traded fuels and sources of energy.

Acceptability is an issue for both traditional and modern energy. This covers many issues: deforestation, land degradation or soil acidification at the regional level; indoor or local pollution such as that exists in Africa and Asia from burning traditional fuels, or in China or South Africa because of poor quality coal briquettes; greenhouse gas emissions and climate change; nuclear security, waste management and proliferation; and the possible negative impact of the building of large dams or large scale modern biomass developments.

These principles aspire to harmonize the economic and social development with the energy policies, taking into account, as a major restriction, the environment protection and preservation.

1.2. Terminology

The terms „energy source" and „energy resource" have general utilization, but its significance somewhat differ.

Energy source defines an energy type or an energy carrier, which can be natural or artificially generated, without a quantitative estimation.

Energy resource, combine the type and the amount of energy, prevailing the second issue.

Energy carrier represents the material support of the energy, which allows transporting, converting or utilizing every type of energy. Energy carriers may be a solid, liquid or gaseous material, as well as radiation, electromagnetic field etc.

All the energy resources have a limited potential. These limits may be represented by the entire quantity of energy carrier (like in the case of fuels, uranium, biomass etc.) or the extent of access to the resource potential (like for the wind, solar radiation, tide energy etc.).

Another important aspect is the dynamic character of the energy resources. On the one hand, the resources diminish because mining (e.g. for fossil fuels, but on the other hand increase as a result of prospecting works.

1.3 Classification of energy sources

There exist a lot of energy sources which are now utilized, having different qualities. A classification is indispensable in order to specify the main features of each resource.

Table 1.1. Energy sources classification

Criterion	Categories	Examples
1. Origin	Solar	Solar radiation Wind energy Hydropower Biomass Fossil fuels
	Other (non-solar)	Nuclear energy Geothermal energy
2. Durability	Non-renewable	Fossil fuels Nuclear fuel
	Renewable	Solar radiation Wind energy Hydropower Biomass Geothermal energy
3. Participation to world consumption	Conventional	Fossil fuels Hydropower Nuclear fuel
	Unconventional	Solar radiation Wind energy Biomass Geothermal energy
	Non-commercial	Vegetal and cattle waste
4. The mobility of the energy carrier	Transportable	Fossil fuels Nuclear fuel Biomass
	Non-transportable	Solar radiation Wind energy Hydropower Geothermal energy

1.4 The energy resources characteristics

The importance of a particular resource is determined by its share in the entire energy consumption as well as the trend of this share for the next period of time. To this position contribute a large enough number of features referring to material qualities as well to technological and economic context. While the material qualities are permanent, the context changes frequently. As consequence, the hierarchy of resources changes, too.

The most important features of the energy sources are:

a) the resource extent;
b) the specific energy content;
c) the durability of the resource;
d) the highest rate of resource exploitation;
e) the possibilities of energy conversion (the number of conversion stapes, the conversion efficiency);
f) the transportation possibilities for the energy carrier, (efficiency, costs);
g) the storage possibilities of the energy carrier(efficiency, costs);
h) the non-energetic utilizations of the energy carrier;
i) the environmental consequences of the resource utilization.

If the first three features refer to material qualities of the energy carrier, the next mainly depends on the technological and economic situation at a specified moment. These features offer a realistic base to estimate the relative importance of the natural energy resources.

Fig.1.1. presents a block diagram of the most utilized energy resources as well as the conversion path to the electrical or thermal energy.

1.5 Equalization of primary energy quantities

The energy needs may be covered by many resources and energy carriers. These carriers differ by the type of energy (chemical, mechanical, thermal, electromagnetic, radiation etc.)as well by the specific energy content even within the same class of carriers.

This variety makes heavier evaluating of whole energy production or consumption at national or global scale. A comparison or substitution of different energy carriers can be very useful in different studies having in view the energy survey or the optimal supplying with energy for a certain consumer.

Some criteria may be utilized in this aim.

1.5.1 The specific energy content

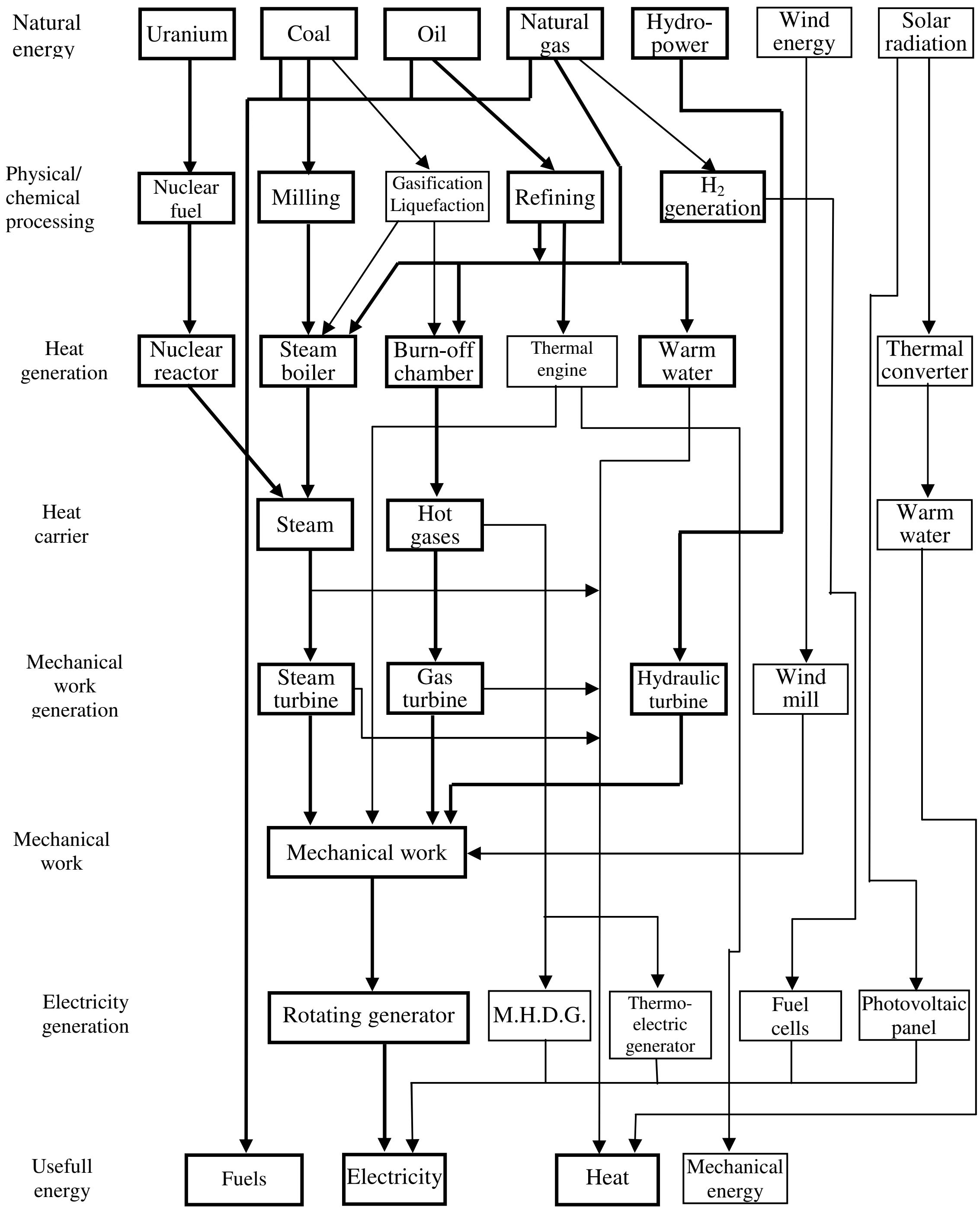

Fig.1.1 Energy sources and conversion processes

This criterion is intended for fossil fuels and biomass, whose specific energy content express by the low calorific (heating) value.

The low calorific value represents the heat amount obtained from the complete burning of a mass (or volume) unity from a certain fuel, without condensing the water vapors and recovering the related latent heat. This parameter is expressed as energy amount for a mass or volume unity of energy carrier. The most utilized unities are kcal/kg, kcal/m^3, MJ/kg, MJ/m^3.

Today, among the primary energy sources the most utilized are the fossil fuels which present a large variety of the low calorific value. Thus the poorest lignite have about 1500 kcal/kg while the best oil reaches over 11000 kcal/kg. In order to express in a concentrated form the global contribution of a large variety of fossil fuels in the energy balance, was very useful to convert the energy content using two conventional categories of fuel:

- the **equivalent coal** (e.c.), having a low calorific value of 7000 kcal/kg 29.3 MJ/kg;
- the **equivalent oil** (e.o.) having a low calorific value of 10000 kcal/kg or 42 MJ/kg.

These conventional fuels were adopted in 1983 by the WEC (World Energy Council).

The conventional quantity of equivalent fuel must have the same energy content as the real amount of fossil fuel:

$$B_{conv} = \frac{q}{q_{conv}} B ,$$

where B_{eqv} and B represent the quantities of equivalent and real fuels,
q_{conv} and q represent the low calorific values of the equivalent and real fuels, respectively.

1.5. 2 The imperfect substitution criterion

This criterion is focused on the electricity share in the whole energy production and consumption. Since the beginning of the XX century, the electricity participation to the energy balance increased more and more. This trend appears to be steadily owing to many important advantages of electricity comparatively with the fuels.

Using the previous criterion to compare the electricity with the fuels, means

1 kWh = 860 kcal = 3.6 MJ = 0.123 kg e.c. = 0.086 kg e.o.

which is correct only for the conversion of electricity into heat but not for the opposite conversion.

Nowadays, over 80% of the electricity is generated through the conversion of the heat into mechanical work in thermal and nuclear power plants. This conversion has a limited efficiency according to the 2nd principle of the thermodynamics, while the electricity can entirely convert into heat.

By this reason, a quantity of electricity may be replaced by the quantity of fossil fuel needed to obtain it in a power plant. Owing to the technological developments the thermal power plant efficiency increased and the specific heat consumption for electricity generation decreased like follows:

- at the beginning of the XX century 1 kWh = 7000 kcal = 1 kg e.c.
- at the middle of the XX century, 1 kWh = 4200 kcal = 0.6 kg e.c.
- at the 8th decade of the XX century, 1 kWh = 2400 kcal = 0.343 kg e.c.

A substitution coefficient may be defined by dividing the heat consumption to generate 1 kWh with the heat physical equivalent of the 1 kWh (860 kcal). This coefficient has decreased from 8.14 in 1900, to 4.88 in 1950 and to 2.79 in 1980. This trend slowed down because the technological limits of the thermal plant processes.

The WEC conference adopted, in 1983, the substitution coefficient of 2.6, thus:

$$1 \text{ kWh} = 2.6 * 860 = 2236 \text{ kcal}$$

The inverse of this number:

$$1/2,6 = 0,385$$

represents the average thermal efficiency of the modern power plants.

The imperfect substitution criterion may be formulate as follows:

„An electricity quantity may be replaced by the thermal energy needed to produce it in a power plant having the world average technological level and working with the average efficiency at a certain moment."

Finally, to replace the electricity with the c onventional fuels, the burning efficiency must be considered, namely the boiler efficiency.

1.2.4.3 Final energy consumption criterion

A same manufacture process may be supplied with energy, starting from different natural resources and passing through different converting, transporting and distribution processes.

The reasonable designing of an energy supplying structure suppose, besides providing the needed amounts, a minimum consumption of primary energy carrier. In this manner, considering the same final output of the production process, the energy efficiency becomes highest, and the energy intensity too.

A such objective can be reached through a detailed analysis, in reverse order, of the energy supplying system, starting from the final use and passing back through the chain of the implied energy processes until the primary resource. Only a comparison of the amounts of primary energy needed for the same final use may be useful to consider all the implications of the energy consumption for the specified end.

Fig. 1.2 presents the result of an energy analysis of a technological process - the warm up of metal bars before forging. The electric warm process proved to be more economic than the natural gas burnig.

The application of this manner of energy analysis need advanced and detailed knowledges about the energy conversion, transmission and distribution processes as well as about the final use of energy. The obtainable results are very useful to establish an ierarchy of the available energy sources and conversion processes related to a certain final use process.

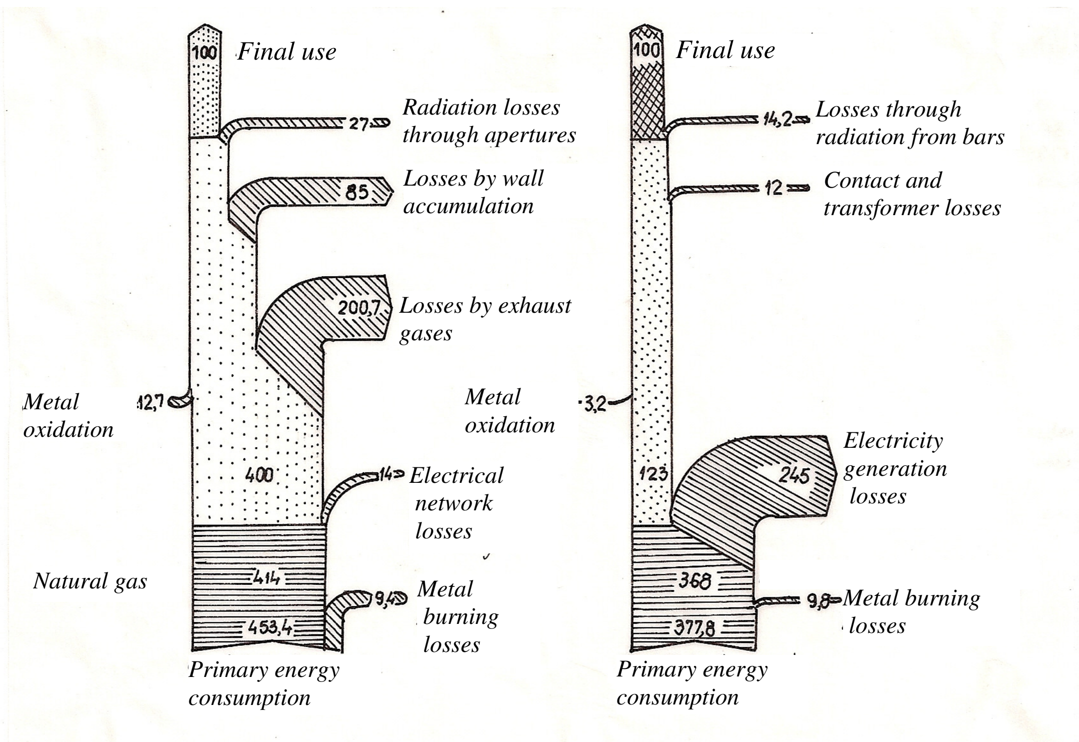

Fig.2.2. Sankey energy diagrams for metal warm up processes:

a) the conventional method, by natural gas burning in furnace;

b) the electrical warm up process by conduction.