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SEC2T (Renewable Energy and Energy Harvesting)

Topic - Fossil Fuels and Alternate Sources of Energy

Introduction:

Our current living standard could not be maintained without energy. The provision of energy or more precisely of the related energy services (e.g. heated living spaces, information, and mobility) involves a huge variety of environmental impacts which are increasingly less tolerated by the society of the 21st century. That's why the "energy problem" in conjunction with the underlying "environmental problem" continues to be a major topic in energy engineering, as well as in the energy and environmental policies worldwide.

From the current viewpoint, this attitude is not expected to change within the near future; the worldwide controversy about the potential risks of the anthropogenic greenhouse effect is only one example. On the contrary, in view of the increasing knowledge and recognition of the effects associated with energy utilization in the broadest sense of the term, increased complexity has to be expected. Against this background, the dimensions of global energy system will be illustrated. However, first some energy terms are defined.

Energy Terms:

According to Max Planck, energy is defined as the ability of a system to cause external action. In this respect the following forms of energy are distinguished: mechanical energy (i.e. potential or kinetic energy), thermal, electric and chemical energy, nuclear energy and solar energy. In practical energy appliances, the ability to perform work becomes visible by force, heat and light. The ability to perform work from chemical energy, as well as nuclear and solar energy is only given if these forms of energy are transformed into mechanical and/or thermal energy.

Energy carriers. A carrier of the above defined energy is a substance that could be used to produce useful energy, either directly or by one or several conversion

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processes. According to the degree of conversion, energy carriers are classified as primary or secondary energy carriers and as final energy carriers. The respective energy content of these energy carriers consists of *primary energy*, *secondary energy* and *final energy*. Definitions of the individual terms are given below, following Fig. 1.

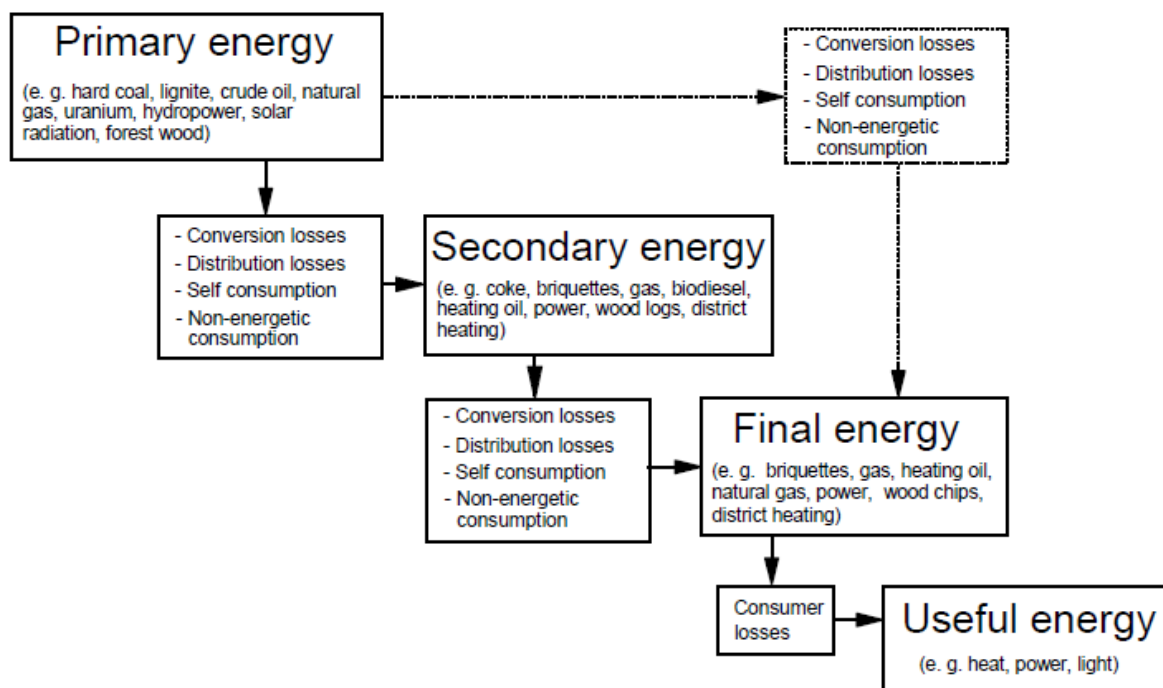


Fig. 1

Primary energy carriers. These are substances which have not yet undergone any technical conversion, whereby the term primary energy refers to the energy content of the primary energy carriers and the "primary" energy flows. From primary energy (e.g. wind power, solar insolation) or primary energy carriers (e.g. hard coal, lignite, crude oil, and biomass) secondary energy or secondary energy carrier can either be produced directly or by one or several conversion steps.

Secondary energy carriers. These are energy carriers that are produced from primary or other secondary energy carriers, either directly or by one or several technical conversion processes (e.g. gasoline, heating oil, rape oil, electrical

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energy), whereby the term secondary energy refers to the energy content of the secondary energy carrier and the corresponding energy flow. This processing of primary energy is subject to conversion and distribution losses. Secondary energy carriers and secondary energies are available to be converted into other secondary or final energy carriers or energies by the consumers.

Final energy carriers. This type of carrier and energy respectively are energy streams directly consumed by the final user (e.g. light fuel oil inside the oil tank of the house owner, wood chips in front of the combustion oven, district heating at the building substation). They result from secondary and possibly from primary energy carriers, or energies, minus conversion and distribution losses, self consumption of the conversion system and non-energetic consumption. They are available for the conversion into useful energy.

Useful energy. It refers to the energy available to the consumer after the last conversion step to satisfy the respective requirements or energy demands (e.g. space heating, food preparation, information, transportation). It is produced from final energy carrier or final energy, reduced by losses of this last conversion (e.g. losses due to heat dissipation by a light bulb to generate light, losses of wood chip fired stove to provide heat).

The available energies or energy carriers can be further subdivided into *fossil biogenous*, *fossil mineral* and *renewable energy* carriers.

Fossil biogenous energy carriers. They primarily include the energy carriers coal (lignite and hard coal) as well as liquid or gaseous hydrocarbons (such as crude oil and natural gas). A further differentiation can be made between fossil biogenous primary energy carriers (e.g. lignite) and fossil biogenous secondary energy carriers (e.g. gasoline, diesel fuel).

Fossil mineral energy carriers. They comprise all substances that provide energy derived from nuclear fission or fusion (such as uranium, thorium, hydrogen).

Renewable energy carriers. They refer to primary energies that are regarded as inexhaustible in terms of human (time) dimensions. They are continuously

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generated by the energy sources solar energy, geothermal energy and tidal energy. The energy produced within the sun is responsible for a multitude of other renewable energies (such as wind and hydropower) as well as renewable energy carriers (such as solid or liquid biofuels). The energy content of the waste can only be referred to as renewable if it is of non-fossil origin (e.g. organic domestic waste, waste from the food processing industry). Properly speaking, only naturally available primary energies or primary energy carriers are renewable but not the resulting secondary or final energies or the related energy carriers. For instance, the current generated from renewable energies by means of a technical conversion process itself is not renewable, since it is only available as long as the respective technical conversion plant is operated. However, in everyday speech secondary and final energy carriers derived from renewable energy are often also referred to as renewable.

Applications of Renewable Energies:

Provision of final or useful energy using renewable energies is based on energy flows originated by the movement and gravitation of planets (i.e. tidal energy), heat stored and released by the earth (i.e. geothermal energy) and in particular energy radiated by the sun (i.e. solar radiation). There is thus a great variety of renewable energies in terms of energy density, variations of the available forms of energy and the related secondary or final energy carriers and final energy to be provided. Each technical option for utilizing the described renewable energy flows or carriers must be adapted to the corresponding characteristics of the available renewable energy; there is thus a broad range of current and also future technical processes and methods to exploit the renewable energy options most successfully.

The three sources of renewable energies give rise to a multitude of very different energy flows and carriers due to various energy conversion processes occurring in nature. In this respect, for instance, wind energy and hydropower, as well as, ocean current energy (as energy flows) and solid or liquid biofuels (as energy carrier; i.e. stored solar energy) all represent more or less conversions of solar energy (as seen in Fig. 2).

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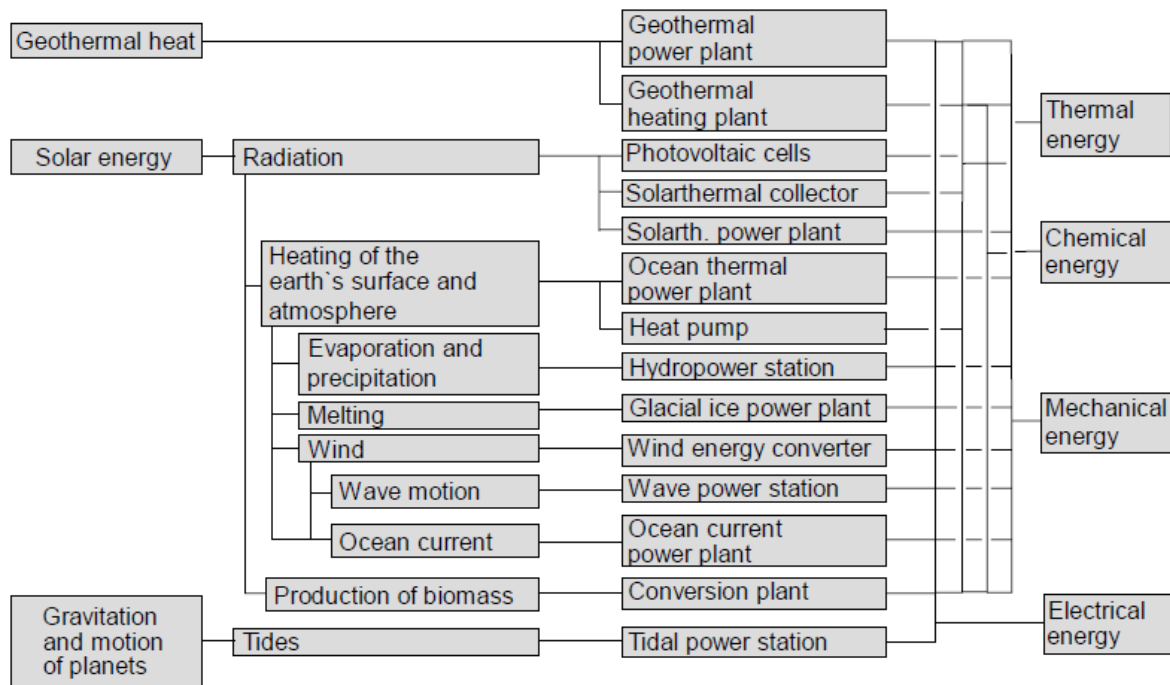


Fig. 2

The energy flows available on earth that directly or indirectly result from these renewable energy sources vary tremendously, for instance, in terms of energy density or with regard to spatial and time variations. They mainly include

- (i) Solar radiation,
- (ii) Wind energy,
- (iii) Hydropower,
- (iv) Photo-synthetically fixed energy and
- (v) Geothermal energy.

Investigated possibilities. Appropriate techniques permit the exploitation and conversion of different renewable energy flows or energy carriers into secondary or final energy, energy carriers or useful energy, respectively. Currently, there are tremendous variations in terms of utilization methods, status

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of technology and given perspectives. Moreover, not all options are possible for every site and every set of boundary conditions.

Therefore only those opportunities that are most promising from the current viewpoint will be investigated in more detail in the following. They include:

- (i) Solar heat provision by passive systems (i.e. architectural measures to use solar energy),
- (ii) Solar thermal heat provision by active systems (i.e. solar thermal collector systems),
- (iii) Solar thermal electrical power provision (i.e. solar tower plants, solar farm plants, solar chimney plants),
- (iv) Photovoltaic conversion of solar radiation into electrical energy (i.e. photovoltaic systems),
- (v) Power generation by wind energy (i.e. wind turbines),
- (vi) Power generation by hydropower to provide electrical energy (i.e. hydro-power plants),
- (vii) Utilization of ambient air and shallow geothermal energy for heat provision (i.e. utilization of low thermal heat by means of heat pumps),
- (viii) Utilization of deep geothermal energy resources for heat and/or power provision (i.e. utilisation of the energy stored in deep porous-fractured reservoirs by means of open and closed systems) and
- (ix) Utilization of photosynthetically fixed energy to provide heat, power and transportation fuels (i.e. energy provision on the basis of biomass).

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Reference:

Renewable Energy: Technology, Economics and Environment, Martin Kaltschmitt, Wolfgang Streicher and Andreas Wiese, Springer

(All the figures have been collected from the above mentioned reference)

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