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The difference between Energy-materials and Eco-materials

by

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Abstract

Energy supply is one of the most essential issues for modern life and the demand worldwide is increasing, but with present technology it is unsustainable. The fossil energy sources give too much burden to the environment and the “energy question” is rising up: Will there be sufficient renewable energy resources and technological development to supply our worldwide increasing demand? New technology requires new materials. Energy materials are materials for the equipment used for harvesting of energy from the resources with best efficiency. Eco materials have the main function to protect the environment. In this paper the differences are discussed, but there are however, also materials, which can do both energy supply and environmental protection, like photovoltaics, thermoelectrics and any energy saving material.

Keywords: Renewable energy, material development, environment protection

1. Introduction

Any new technology requires the development of new materials with better properties than materials before. And any new discovery of new properties leads to new technologies. Energy materials are materials for the equipment used for harvesting of energy from the resources with best efficiency. The fuels itself like fossil fuels, oil, coal, gas as consumption material are usually not included. Eco materials are materials for the equipment used for protection of the environment on our planet earth.

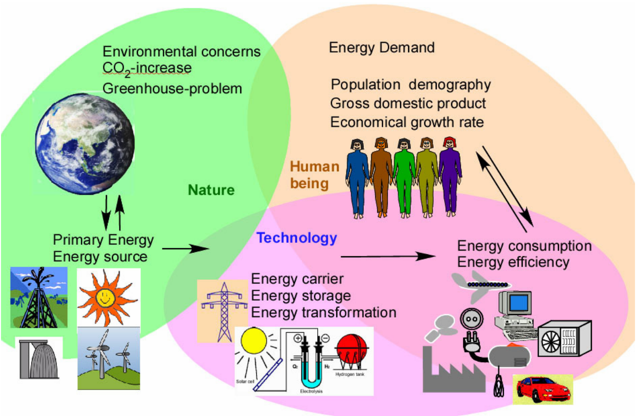

Fig. 1 Energy supply should be in harmony with nature, using the most efficient technology for supporting the demand of a comfortable life for human beings.

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Fig. 1 shows the scheme of the energy supply, which should be in harmony with nature, human beings and technology. The still increasing population on earth and the rising living standard lead to an increasing energy demand. The average energy demand *Ed* depends on the number of people *P*, the gross domestic product *GDP* as a measure for the living standard and an additional demand related to the economical growth rate *g* for building industries and infrastructure: $Ed = P * GDP * (1+g)$. The energy demand has also daily, monthly, and yearly fluctuations and everybody wishes a permanent and secure electricity supply.

The dramatic increase of the CO_2 concentration in the atmosphere and the steadily rising average temperatures show, that the present energy consumption is not sustainable [1]. Meanwhile it is well accepted that the temperature increase is man-made caused by the greenhouse effect of burning fossil fuels [2]. In the Kyoto protocol politicians of leading countries agreed that the environment should be protected by reducing the CO_2 emission. Environmental friendly reduction of CO_2 emission is the challenge of our century. Eco materials such as ceramic filters in combustion power plants or ceramic catalysts in cars have brought a large success in reducing flying ash and NOx concentration, but for the separation and storage of CO_2 at present no cheap solution has been found. With our present technology we are using worldwide in average as primary energy mix about 70% fossil raw materials (coal 20%, oil 30%, gas 20%), 20% nuclear energy and only 10% renewable sources, like hydro, solar thermal, photovoltaic, wind, biomass and others [1,2]. The present energy support of industrial countries puts too much burdens on the environment and many people fear about the problem of energy support in future, the so-called "energy question": Will there be sufficient energy resources and technological development to supply our worldwide increasing demand? Will this energy support by sustainable without to many burdens for environment and future generations? Consequently this leads to the final question: Can our civilization on planet Earth survive? The answer is hard to predict and depends on the effort of researchers and the will of politicians, as discussed in the following.

2. Definition

Energy materials are materials for the equipment used for harvesting of energy from the resources with best efficiency. Hence, energy materials are all the materials used in technology to convert the primary energy into the energy carrier which arrives at the consumer as secondary energy and finally in the end energy which is actually used for the purpose of human beings, such as air conditioning, comfortable life, transportation and production of goods.

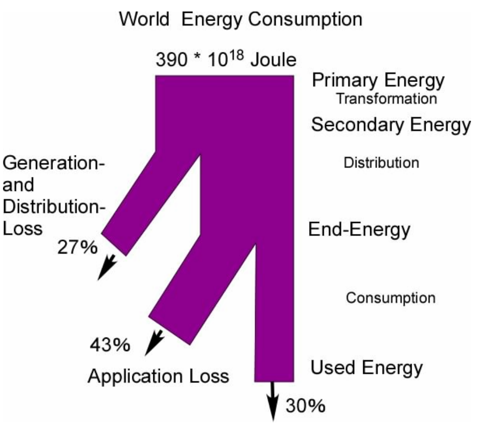

Fig. 2 Challenge for future energy materials is to reduce the loss during generation, distribution and application of energy

Fig. 2 shows that with the present technology there is a large amount of loss in each step of energy transformation. From the primary energy, which is stored in the fuels or which comes as renewable energy, only 63% is distribution as secondary energy to the consumer [1]. The losses are due to inefficient technology, unsuitable equipment, heat dissipation, transportation or storage losses and others. The present energy carriers are electricity and gasoline, and materials researcher work hard on the fuel cell in order to use hydrogen as new energy carrier to substitute gasoline and batteries in many applications. This vision of a new hydrogen society [2] requires the development of new materials especially of efficient storage of hydrogen [3], corrosion problems [4] and also diffusion barrier materials for hydrogen tanks. At present (fig. 2) at each consumer product or at each production process in average 43% of the end energy is wasted and finally only 30% is actually used in the application. It is a challenge for any engineer to reduce the loss of energy in each of the steps, namely in energy conversion, distribution and consumption.

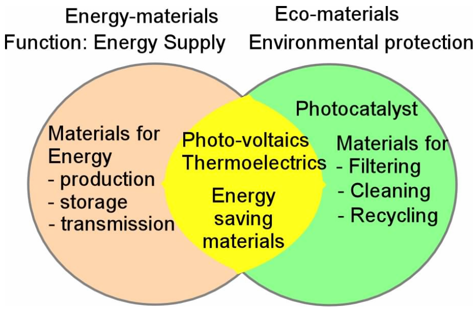

Fig. 3 Energy materials have the main function to support energy-production, -storage or –transmission, while eco-materials have the main function to protect the environment by filtering exhaust fumes, or clean and recycle industrial waste. Energy saving materials, photovoltaics and thermoelectrics combine both functions.

The tasks for engineering are clear: Find new technologies for energy support but with as strong protection of the environment as possible. Any new technology is strong related to new materials. Energy materials as shown in fig. 3 have the main function to support energy. Eco materials have the main function to protect the environment. Several Eco materials are distinguished. At international eco-material conferences the session on photocatalyst is the largest [5]. They can clean the air, protection pollution or avoid dust precipitation on surfaces [6]. Other tasks are using non-hazardous materials as substitutes for traditional hazardous materials as well as treatment of waste or the recycling of precious raw materials. Furthermore, there are materials or production processes in order to save the environment or energy, recently referred as reducing the ecological footprint or the ecological backpack [2].

Energy materials are developed by the need of energy support. All the steels for high-temperture, high pressure combustion chambers for buring fossil fuels are included as well as the steels for safe operation of nuclear power plants. Energy materials are gaining from a self-promoting cycle: Companies are interesting in making profit from selling energy to the costumers, for which steadily an increasing demand exsist. Energy is a product for which always a large market is present. These companies are interested in developing efficient and newest technology.

In the case of eco materials the situation is slightly different. There are many positive examples that an increasing demand for environmental friendly materials creates new markets and companies are successfully selling environment-friendly products to costumers who are willing to protect environment. But it should be noticed, that there is no self-promotion: Environmental protection at least costs some amount of money and needs the donation of people or organization that are willing to do something. Nature has a small lobby and politicians need to set by law certain regulations to protect the environment. Only in a few cases such products can save cost, like self-cleaning ceramics coatings interior, exterior or in transportation.

Finally there are materials, which possess both functions, environmental protection and energy supply. All materials for promotion of renewable energy sources can be counted in this category. While power plants working with hydroenergy, geothermal or tidal energy can be built with available materials, in the case of wind energy it could only be utilized in large wind turbines, after ultra-light carbon-fibre reinforced plastics (CFRP) with high strength were available, which were originally developed for aircraft applications. Energy supply by solar thermal energy is successful on small scale, like a boiler on the roof of a house. For large scale applications, like in powerplants [8], however, the direct conversion from light into electricity in photovoltaic materials has a better chance of success, because it needs no maintance on moving parts and has overall fewer burdens to the environment.

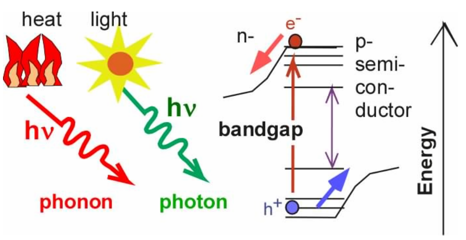

Fig. 4. There is a strong relationship between thermoelectrics and photovoltaics: The electrons are excited across the bandgap at interfaces of p/-n semiconductors either by phonons (heat) or by photons (light). To avoid recombination, fast seperation of the charge carriers at the p/n interface is essential.

The principle of solar cells is shown in fig. 4. The excitation of electrons by light in a semiconductor creates a pair of electrons and holes, which are sepreated by the electric field at a n/p-semiconductore interface. Materials research focus especially on the increasing the efficiency but also searching for dyes for light absoption or in new materials which make flexible solar cells applicable [9]. Fig. 4 also shows that almost the same principle is working for a thermoelectric materials, which can convert heat directly into electricity, also without any maintance on moving parts. Although at present the efficiency is not large enough to compete with the presently used Carnot process in heat-electricity converters like steam turbines [10], large research activities in Japan and USA started and understanding the principle [11] will make these materials soon be important for energy supply on a large scale.

Bi-functional materials, which fulfill both, the energy support and the enviromental protection are hence all materials, which support clean energy sources like photovoltaics, thermoelectrics, wind, water, bio energy. Additionally the energy saving materials can be included, like wall insulation or any material which reduces energy in electric devices. These two examples are discussed in the last chapter.

3. Examples of environmental friendly energy materials

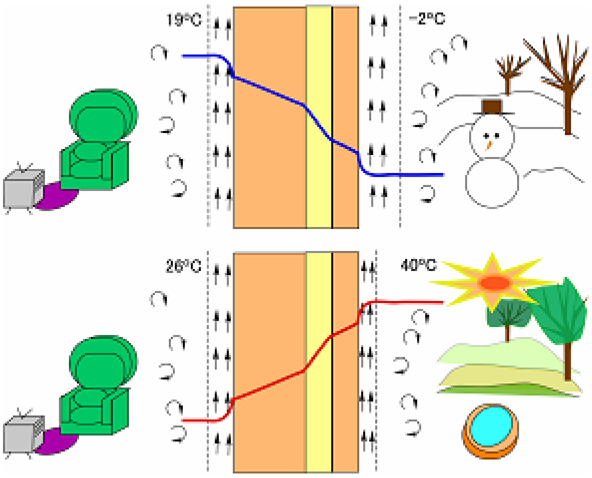

Fig. 5. Energy saving material for house wall insulation: The temperature profile between living room on the left side and outside on the right side is optimized by materials with low heat conduction.

More than one third of overall energy is sent for maintaining a comfortable temperature at home or at work. Fig. 5 shows the example of an energy saving material. The wall of houses can keep a moderate temperature of 19°C in winter in the living room, even if outside are minus temperatures. In summer time, the severe heat and heat irradiation with temperatures up to 40°C should be lock out and the temperature inside should be kept comfortable, at least less than 26°C. The temperature profile shows, that special materials with low thermal conductivity in between the layers of the wall and the decoration can provide a large temperature gradient. Porous ceramic based materials are successful, because the air in the pores has the loweste thermal conductivity. For transportation, especially commuter trains, most heat comes through the windows and engineers have developed glass coated with gold thin films in order to cut the ultra-violet light. The saving in energy is enormous.

Fig. 6. Railways are the transportation systems with fewer burdens to environment. Japan is the world-wide leading country concerning commuter trains and has introduced high speed trains at first. Such a Shinkansen train is passing Mount Fuji and our Tokai University, Shonan Campus near Hiratsuka City.

Fig. 6 shows the Japanese Shinkansen high-speed train as an example for the most environmental friendly transport system. Electricity has the lowest emission of CO_2 compared to other present fuels for transport and higher transformation efficiency than the Carnot process used in combustion engines. Also compared to road for cars or truck, a railroad for the same capacity needs only 1/3 of the space. Furthermore, the control of the traffic is much easier and denser traffic can be achieved, even though in the ubiquitous age car distance controllers are in development. Japanese engineers work already on the next generation of high-speed linear motorcars, which use superconductors [12] along the track in order to further reduce the energy consumption.

As a summary of this paper, it can be concluded that the creativity and effort of engineers can presumably develop new materials with higher energy conversion efficiency. Through new technologies, new energy saving materials and larger support of green energy sources, the environmental problems can presumably be solved in the near future. One condition is that politicans show the will to protect the enviroment and support sufficient research fondings.

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