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SOLAR ENERGY: PROSPECTS AND PROBLEMS

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In this paper the prospects of use of solar energy are discussed. The advantages and problems of solar energy, and also methods of preparation electric energy and heat from sunlight are considered.

1. INTRODUCTION

Energy is the key factor of social and economic development. It also is in the center of the economic, social and ecological purposes of steady development. Consumption of energy per capita is a parameter of the technical civilization level, and the level consumption of energy till now does not find out the tendency to decrease, and on the contrary, increases every year. The annual gain of the general consumption of energy in the world for last 30 years has on the average made 2 percent [1]. However, the level of world consumption of energy per capita for this time practically has not changed, though the general consumption has increased approximately for 70 percent.

As shown in materials of a symposium «Electrochemistry. 30 years of the past and 30 years of the future» which took place in 1975 in London and [2], during last one million years (up to 1975) the humanity has consumed as a whole nearby 13 Q* energy, which most part (10.5 Q) is obtained at combustion of wood and other natural materials. The annual speed of consumption of energy then made 0.15 Q. If to consider, that the annual gain of consumption of energy in the world on the average makes 2 percent it is easy to show, that for the expired years the humanity has consumed in addition 6.3 Q energy, and annual speed of consumption of energy today makes approximately 0.3 Q.

Now the basic part of world energy balance is necessary on a share thermal and atomic engineering. However, the main problem of modern energy on the one hand is related to exhaustion of mineral resources [3] and on the other hand - with ecological conditions. The prize of humanity from manufacture and consumption of energy frequently turns around negative ecological consequences which, in turn, can render negative influence on health and quality of a life. How conceivable resources will be used all to burst ecological accident which will transform the Earth into the planet which absolutely not has been not adapted for human life. Therefore, the humanity

* 1Q energy is equal to 10^{18} B.T.U. (B.T.U – is the British caloric unit, which equals 0.252 kcal) and can to take by processing the $38 \cdot 10^9$ t of coal.

should refuse thermal energy. Apparently, it is necessary to limit also atomic engineering. The matter is that each atomic energy station, independently of the reliability degree, is, as a matter of fact, a stationary nuclear bomb which can be at any moment blown up by diversion, bombardment from air, bombardment by rockets or the usual artillery shells, playing the role of detonator. Real danger is also radioactive waste of atomic energy stations. However, the atomic engineering has also important advantages. For example, the American experts have counted up, that if to the beginning of 90th years in the former USSR atomic energy stations would replace all on coal the same capacity air pollution would become great. It is so great, that it would lead to 50-fold increase in premature death in XXI century in comparison with the most pessimistic forecasts of consequences of Chernobyl accident. Therefore the small share of atomic engineering nevertheless should be left in the world energy balance.

It is clearly from mentioned, that the future energy should lean to the *alternative energy* based on use renewable or «pure» energy sources among which the important place is take solar energy. The energy of the future will be based basically on solar energy (> 50 %). The volume of manufacture of solar photoelectric systems now grows on the average on 30 % per year. The rate on solar energy should be considered as a safe and uncontested choice for humanity. In the given work advantages and problems of solar energy, and also methods of preparation electric energy and heat from sunlight are discussed.

2. ADVANTAGES OF SOLAR ENERGY

The following factors define a great value of solar energy for world economics [4]:

- to the middle of century stocks of oil and gas will be close to an exhaustion, and the solar electricity should compensate their decreasing extraction;
- an increasing emission of carbon dioxide in the atmosphere should lead to the accelerated development of ecologically pure solar photo-energy for decrease in a level of pollution of environment and global warming;
- the general availability and inexhaustibility of source; the solar electricity will be a dominating energy source from shares approximately 60% by the end of century owing to practically not exhausted resource of energy of sunlight.
- The use of solar batteries does not change energy balance: all energy coming from the Sun after transformation to the electric energy or warmly remains near to that place where this transformation is carried out. It is one of the basic advantages of solar photo-energy also consists: the solar energy is equally accessible to all earthmen, and solar energy is the most democratic kind of energy.
- Theoretically, full safety for an environment.

Except for these factors, a concerning energy, there are also the social factors stimulating development of solar photo-energy:

- More than two billions people in the world have no access to the centralized supply by electricity, and the majority of them lives in solar belt of the Earth. The centralized system of supply by the electric energy is not favorable in a number of these areas, and its creation would demand huge capital investments.

• The latent social expenses for indemnification of harmful influence of fuel energy stations (illness, reduction of life expectancy, etc.) are distributed on all society and make 50-80 % of the prices on energy. If to include these expenses directly in tariffs for fuel and energy the photo-energy becomes competitive already at the given stage of its development.

3. THE WAYS OF RECEPTION OF AN ELECTRICITY AND HEAT FROM SUNLIGHT

3.1. Manufacture of the electric energy by means of photocells

The photoeffect in semiconductors already more than century is intensively investigated in laboratories and is widely used in practice. Wide practical use for the energy purposes of solar batteries has begun with start in 1958 of artificial satellites of the Earth - Soviet «Sputnik-3» and American «Vanguard-1». From now on here already more than 35 years semiconductor solar batteries are basic and almost unique source of energy supply of space apparatus and greater orbital stations.

Still more recently believed that the photoelectric method of transformation of a solar energy has prospects of development for ground energy only for the decision of private problems - for example, for independent systems of energy supplies in the remote or removed areas. So, for example, in 1975 total capacity of all solar electroinstallations on semiconductor photocells made about 300 kW in cost more than 20 thousand dollar for peak kilowatt of capacity.

The development of new methods of manufacture of semiconductor silicon, development of new materials and creation of essentially new types of photoelectric converters on heterojunctions cardinally change now position in this area. The efficiency of silicon photocells for laboratory samples has exceeded 20 %, silicon photocells from efficiency up to 15 % are widely used in practice. Solar photoelectric elements are converters of energy of thermal radiation of source with temperature 5800 K (temperature of radiating surface of the Sun). Therefore their limiting theoretical efficiency according to the second law of thermodynamics is equal 93 %, and real- 87 %. The expected values of efficiency cascade heterojunction photoconverters is about 50-55 %, and the reached values already have exceeded 40 %. The nearest 10 years efficiency will reach 50 %.

Now as photoelectric elements basically monocrystalline, polycrystalline and thin-film silicon photocells are used. In 2006 thin-film photo cells borrowed 7 % part of the market. In 2005 on thin-film photo cells was necessary 6 % of the market. In 2007 the part of thin-film technologies will increase up to 8 %. For the period from 1999 to 2006 of delivery of thin-film photocells grew annually on the average on 80%.

3.2. Heliothermal energy

Heating of the surface absorbing solar light both the subsequent distribution and use of heat (focusing of sunlight on a vessel with water for subsequent use heated waters in heating or in steam electrogenerators).

The Solar energy is widely used both for heating water, and for manufacture of the electric energy. In second half of last century, alongside with accruing development of solar photoenergy, in many countries big enough attention was paid to development and creation of solar thermal energy stations in which the concentrated sunlight heated up the heat-carrier, and formed then in a boiler of pairs actuated turbo-electric generator. Such solar energy stations up to 10 MW have been created by capacity in the USA, France, Spain, Italy and other countries, including in the USSR. Some of these stations still work, many have stopped functioning, but it is possible to approve with confidence that they essentially cannot compete to solar photoelectric systems. In solar thermal energy installations the maximal temperature of heating of working body usually does not exceed 1000 K, and in the most widespread steam-turbine installations is at a level nearby 500 K. It means, that their limiting theoretical efficiency, equal efficiency of Carno cycle, makes about 40 %, and real- no more than 20-25 %.

The solar collectors are made from accessible materials: steel, copper, aluminum, etc., i.e. without application of scarce and dear silicon. It allows considerably reducing cost of the equipment, and the income energy on it.

The solar collectors can be applied also to cooking. The temperature in focus of a collector reaches 150°C. Such kitchen devices can widely be applied in developing countries in which for cooking fire wood are actively used. The traditional centers for cooking have thermal efficiency about 10%. Use of fire wood for cooking leads to the massed cutting down of woods. For example, in India from burning a biomass annually acts in an atmosphere more than 68 million tons CO_2. Housewives at cooking inhale a plenty of a smoke that leads to increase in disease of respiratory ways.

3.3. The sources constructed on dynamic transformation of solar energy with thermal accumulation of energy

In spite of the fact that photoelectronic sources are widely used in space, solar dynamic energy installations have appeared more effective and less expensive. The principle of work of solar dynamic installations consists in the following: solar beams are focused by a parabolic reflector on the receiver which heats up the working body actuating the engine or the turbine. Then mechanical energy will be transformed by the generator in electric. For accumulation of thermal energy is used salt, which is melt in the receiver. During blackout salt cools down and gives heat for expansion of a working body. The efficiency of solar dynamic energy installations is about 20-30%. Efficiency of the thermal store more than 90 %, accumulator batteries- 70-80 %, fuel elements- 55 %. Higher efficiency allows reducing the area of the collector of solar energy that facilitates the decision of problems of dynamics of station.

To accumulation of energy apply fuel elements, nickel-cadmium and nickel-hydrogen of the battery. The fuel elements accumulate excess electric energy, received from solar battery, by means of generation of oxygen and hydrogen during water electrolysis. The electric energy then can be received from thermal which is allocated at connection of the saved up oxygen and hydrogen. Such method of accumulation of electric energy is considerably flexible also fuel elements much easier batteries, but has low efficiency and reliability.

The nickel-cadmium batteries are made on the basis of well fulfilled technology. They already for a long time are successfully used in space apparatus though low depth of the category leads to substantial growth of their weight. The nickel-hydrogen of batteries have been chosen for space platforms as they are more reliable, than fuel elements, and thus on 50 % it is easier, than nickel-cadmium batteries.

3.4. «Solar sail»

«Solar sails» can transform solar beams in a vacuum to kinetic energy.

3.5. Thermal-air energy stations

The transformation solar energy in energy of the air stream directed on a turbogenerator.

3.5. Solar balloon-borne energy stations (generation water pair inside of cylinder of a balloon due to heating by sunlight of surface of the balloon covered by selective-absorbing covering). Advantage - pair in cylinder is enough stock for work of energy station during dark time of day and in rainy weather.

4. LACKS OF SOLAR ENERGY

4.1. Fundamental problems

- The stream of the sunlight which is passing through platform in $1m^2$, located perpendicularly to stream of radiation on distance of one astronomical unit from the center of the Sun (that is outside of an atmosphere of the Earth), it is equal 1367 W/m^2 (a solar constant). Because of absorption by an atmosphere of the Earth, the maximal stream of sunlight on a sea level is about 1020 W/m^2. However it is necessary to consider, that daily average value of stream of the sunlight through an individual platform at least three times is less (because of change of day and night and change of a corner of the sun above horizon). In the winter in the moderate breadths this value in two times is less. This quantity of energy from unit of the area defines opportunities of solar energy. The prospects of development of solar energy also decrease because of global blackout - anthropogenous reduction of the sunlight reaching a surface of the Earth.
- Because of rather small size of a solar constant for solar energy use of greater areas of the ground under energy stations (for example, for energy station capacity 1 QW it can be some tens square kilometers) is required. However, it is lack not so it is great; for example, the water-energy engineering deduces noticeably greater sites of the ground from using. Besides photoelectric elements on large solar energy stations are established at height of 1.8-2.5 m that allows to use the grounds under energy station for agricultural needs, for example, for pasture cattle.
- The stream of solar energy on surface of the Earth strongly depends on breadth and climate. In different places the average quantity of sunny days in a year can differ very strongly.

4.2. Technical problems

• The Solar energy station does not work at night and insufficiently effectively works in morning and evening twilight. Thus the peak of energy consumption is necessary at evening o'clock. Besides capacity of energy station can change sharply and unexpectedly because of change of weather. For overcoming these lacks it is necessary or to use effective electric accumulators (for today it is not solved problem), or to build storage installations which too borrow greater territory, or to use the concept of hydrogen energy which also while is far from economic efficiency. The problem of dependence of capacity of a solar energy station from time of day and weather conditions is solved in case of solar balloon-borne energy stations.

• Dearness of solar photo cells. Possibly, with development of technology this lack will overcome. In 1990 - 2005 of the price for photo cells decreased on the average on 4 % per year.

• Insufficient efficiency of solar elements (it is probable, will be soon increased).

• The surface of photopanels needs to be cleared from dust and other pollution. At their area in some square kilometers it can cause difficulties.

• Efficiency of photoelectric elements noticeably falls at their heating, therefore there is necessity for installation of systems of cooling, usually water.

• In 30 years of operation efficiency of photoelectric elements starts to decrease.

4.3. Environmental problems

• Despite of ecological cleanliness of received energy, photocells contain poisonous substances, for example, lead, cadmium, gallium, arsenic, etc., and their manufacture consumes weight of other dangerous substances. The modern photocells have the limited service life (30-50 years), and mass application will put during the nearest time a complicated question of their recycling, which too not while comprehensible decision from the ecological point of view.

• Because of environmental problems and the arisen deficiency of silicon manufacture of thin-film photocells in structure of which 1 % of silicon contains all nearby starts to develop actively. Besides thin-film photocells are cheaper in manufacture but while have smaller efficiency.

• There is probability of that universal introduction of solar energy can change albedo of terrestrial surface and lead to change of climate (however at modern consumption level of energy it is extremely improbable).

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GÜNƏŞ ENERGETİKASI: PERSPEKTİVLƏR VƏ PROBLEMLƏR

A.H.KAZIMZADƏ, H.M.MƏMMƏDOV

XÜLASƏ

İşdə günəş energetikasından istifadə perspektivləri və problemləri müzakirə edilir. Günəş energetikasının üstün cəhətləri və problemləri, həmçinin günəş şüalanmasından elektrik enerjisinin və istiliyin alınması üsulları təhlil edilir.

СОЛНЕЧНАЯ ЭНЕРГЕТИКА: ПЕРСПЕКТИВЫ И ПРОБЛЕМЫ

А.Г.КЯЗЫМ-ЗАДЕ, Г.М.МАМЕДОВ

РЕЗЮМЕ

В работе обсуждаются перспективы использования солнечной энергетики. Рассматриваются достоинства и проблемы солнечной энергетики, а также методы получения электрической энергии и тепла из солнечного излучения.