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# Solar energy:
## heat conversion of solar radiation

# SOLAR ENERGY: HEAT CONVERSION OF SOLAR RADIATION

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## ABSTRACT

*The energy of sunlight is the most completely clean source of energy that is available to man, but only the threat of climate change impacts and reduction of fossil fuel reserves has affected the sun energy being in the past twenty years the only guarantor of options to meet energy needs in the upcoming long term.*

*This paper explains why Serbia does not use solar radiation thermal conversion, despite much greater potential in relation to the countries of Western Europe leading in the application of solar energy.*

*Low population standard, small electrical energy price, low level of energy efficiency in all areas of spending energy and lack of knowledge and political decisions are the main causes of insufficient application of renewable energy sources in Serbia.*

*Although in the winter energy effect of solar radiation is lower than in the summer, it is still very significant for the solar heating of homes, as support to other energy in the central heating system, where it can cover about 45% of free thermal energy for heating homes and about 75% for heating sanitary water. The best effect of using solar energy for solar heating of family homes and other residential and business buildings can be achieved in transitional periods with energy efficient heating systems i.e. floor - wall heating systems, i.e. low temperature heating systems.*

*However, due to changeable force of solar radiation during the day, month and year, installing solar heating, which would enable fully heating throughout the winter period cannot be done, and the solar systems for solar heating are combined with other sources of energy that spent other forms of energy: liquid fuel, gas fuel, electrical energy, solid fuel and the like.*

*As an inevitable prerequisite for the development of the utilization of solar energy in our country, there is a necessity to direct and finance the domestic knowledge in the field of the heat conversion of solar radiation to achieve adequate results:*

- *reducing energy dependence*
- *increasing the employment of the population*
- *reducing family energy costs and thereby contributing to poverty reduction*
- *reducing pollution of our environment.*

*However, the proposals for increasing domestic participation in the energy sector in Serbia, which are mentioned in this article, mostly apply to all other renewable energy sources.*

# INTRODUCTION

The decision of the European Union to increase the share of renewable energy sources to 20% of the total production by 2020 is a good indicator of the situation where we are. Mining of coal and its burning in our current and future power plants is our great value, benefit and security, but that does not mean that the energy needs to be wastefully treated. "We should consider the fact that Serbia is a small country with limited reserves of primary energy (excluding reserves of lignite, located mainly in the territory of Kosovo and Metohija), in particular quality of energy, and that the most technically useful and economically justifiable potential has already been used.

Serbia, as a waster of electricity, has a chance, just by saving, rational consumption and increase in overall energy efficiency, to attain excess energy without construction of new power generating capacity. On the basis of this attitude we come to conclusion that the new power plants should be built and that almost all new amount of energy will be available for export. The application of solar energy is only a healthy way to make reduction in energy consumption wherever possible. This means that no matter that the cost of investment in solar energy is quite large, of about 3.000 Euros for 1kW of installed power, it pays to invest in a certain market. If that price also includes everything that follows well conceived and organized work such as research, development, production, marketing, creating professional scientific and production staff, new technologies, export of much of production, employment in primary and related activities, then this price is significantly lower and the full effect is achieved. Then the price of installing 1 kW thermal collectors for the state may be negligible.

Energy Development Strategy of the Republic of Serbia proposes an intensive gasification. This priority envisages the so-called ''Gasification" program, which includes the introduction of gas in about 400.000 new households in Serbia until 2015 with the aim to reduce the need for electricity in the sector, for at least 2.300 GWh, with DER scenario, that is 1.500 GWh, with UER scenario, in which case gas would be provided for at least 260.000 new apartments. [1] This means that 400.000 gas boilers will be installed, because there is no production here. If the same logic is applied to 400.000 solar systems for the heating of sanitary water, it can achieve savings of around 1.000 GWh, while it is quite possible and reasonable to organize local production. In this way, the dynamics of 50.000 solar systems a year or about 100.000 collectors can achieve the creation of a solid industry. What do we need to undertake to be able to export most of the electricity from power plants?

The answer is simple, but its implementation requires a lot to be done. Energy Development Strategy of the Republic of Serbia, by 2015, promotes "selective use of new and renewable energy sources, with the aim of slowing the growth rate of energy imports,

reducing the negative impact on the environment and the opening of an additional activity for local industry and employment of local population, including the adaptation to the EU practices and regulations in the area". [1]

There are four main reasons why Serbia should engage all available forces to significantly increase the use of solar energy now, in a very short period of time, which is very important to us.

1. Over 55% of the total energy is consumed in households in Serbia in the form of electricity, with much energy spent on the sanitary water heating.
2. Reduction in costs for heating sanitary water of about 60 to 70% is achieved in one year, resulting in the relief of the home budget.
3. Increased employment in the research, production, installation and servicing solar equipment.
4. With the significant application of solar power we are getting closer to the recommendations of the European Union on the use of renewable energy sources, which include the sun to a large extent.

## Background

Thermonuclear reactions in the sun and the released energy that has been reaching the Earth from its very creation, about 4 billion years ago, have led to the development and survival of life on our planet. In the course of his development up to a few hundred years ago, the man only used the energy of the Sun to settle all his modest needs.

In addition to the thermal conversion of radiation which occurs in the air, water and on land, the man has most used wood or, in more modern terms, biomass which is the direct product of solar energy from the photosynthesis process.

The theme of this paper is using the thermal conversion of solar radiation we get heat energy. In addition to thermal conversion are increasingly used for the conversion of photovoltaic conversion solar radiation energy directly into electrical energy.

An important feature of the solar radiation is that the energy which in this way comes to land is much greater than all the needs we can imagine in the future. The grandeur of the free energy that is constantly coming in shows in which direction the man should seek security for its growing energy needs. Solar energy thermal conversion takes place on the whole surface of the Earth.

In order for solar energy to be focused and used for our specific needs, it is necessary to make corresponding receiver or collector. Collectors are areas where reception and conversion of solar radiation to thermal energy are taking place. This natural process leads to the absorption of radiation in the material from which the collector is made. The absorbed energy is converted into kinetic electron energy, which is manifested as the heating of the materials. The received thermal energy needs to be taken to the heat storage or to the place where it will be used, using a fluid which is most often water, glycol, oil or air. In the course of one year 1 $m^2$ of collectors can accommodate about 900 kWh of heat energy. [5]

## Thermal conversion

The application of solar energy by thermal conversion in practice is used for:

- Sanitary water heating in homes, apartments, hotels, hostels, student dormitories, homes for the elderly, kindergartens, restaurants and sports facilities
- Heating of sanitary water for villages that have a distribution of hot water from urban heating plants in the period when heating plants are not working.

- Heating pools in homes and sports centers
- Heating water or other fluids in industrial processes
- Heating greenhouses in agricultural production
- Drying agricultural products
- Distillation of water for industrial purposes
- Heating rooms as an additional tool in periods when there are enough sunny days
- Production of electricity based on the thermal conversion of solar radiation (steam turbines)
- In the processes for room cooling

In all points of this list, regarding the application of solar energy, our science and technology can and should give full contribution in order to establish efficient production of domestic equipment.

## Thermal solar collectors

Thermal conversion of solar energy takes place throughout the sun-lit surface of the Earth. In order to direct solar energy and use it for our specific needs, it is necessary to make the corresponding receiver or collector.

Collectors are areas where reception and conversion of solar radiation into heat energy are taking place. This natural process leads to the absorption of radiation in the material from which the collector is made. The absorbed energy is converted into the kinetic energy of electrons which is manifested as material heating. The received thermal energy needs to be taken to the heat storage or to the place where it will be used, using a fluid which is usually water, glycol, oil or air.

Plate collectors are usually an area of about $2m^2$. The back sides are thermally insulated in order to reduce the losses of the colder days, and the front is a highpass glass. Absorber is usually made of aluminum or copper that is coated with electrolytic high absorbing materials that can absorb up to 98% due energy. The efficiency of transformation of energy systems for heating of sanitary water from the collector to solar water heaters, ranges on traditional types of collectors from 35 to 55%. In the course of one year 1 $m^2$ collectors can accommodate about 900 kWh of thermal energy. [5]

Vacuum thermal collectors are characterized by greater efficiency, which especially comes into play in the colder periods. This efficiency is based on a much better thermal isolation absorber which is located in a glass tube from which air is drawn. The overall performance of the system for sanitary water heating with vacuum collectors is at the

annual level about 40% higher than the system with flat plate collectors. Vacuum collector consists of 15 to 30 vacuum tubes, which are associated with the heat exchanger through which fluid flows to be heated. The price of vacuum collectors is for about 50% higher than conventional collectors. For this reason the vacuum collectors are recommended for buildings where there is a constant need for hot water, especially where they need greater amounts of hot water.

## Europe and the world

In the past twenty years, solar thermal conversion has occupied little role compared with other sources of renewable energy. The focus has been directed at the development of areas which produce electrical energy such as wind generators and photovoltaic conversion of solar radiation. The reason for a sudden turnaround is the European Union's making plans for the implementation of renewable energy sources by 2020.

In order to achieve the plans the calculation showed that low temperature application of solar energy has the greatest potential. [2] Due to the neglected development in the previous period low temperature application of solar energy will experience a huge improvement in the immediate future, because 50% of the total energy required for heating can be met by the sun energy. This can be achieved only through a large scientific and research work, testing and implementation in practice. When we know that over 40% of energy in Europe and here is spent on heating it is obvious that in this area the greatest savings by using solar energy can achieve. In Europe, for 20 years building new residential and commercial properties have been subject to innovations and regulations that contribute to energy efficiency. In the future this trend will continue even more intensively in the following areas:

- Construction of new active solar buildings for housing and business
- Renovation of old buildings to meet new demands and become active solar buildings
- The application of solar energy in industry and in all processes where the temperatures required are up to 250°C.

The European Union strategy is planning by 2025, to reduce energy demand by 40% in heating primarily by increasing the energy efficiency, and by 2050 the solar energy is to meet 50% of energy needs for heating. Both processes are already now taking place in parallel. [2]

The European Union is planning by 2030, the installation of thermal solar collectors of the total heat power of 970GW. Slovenia by the end of 2008 had installed 96MW or

137.000m$^2$ of thermal solar collectors with an annual increase of about 33%. [6] In India, the state began project to install 7.000.000m$^2$ of thermal collectors for the period from 2010 to 2013 and 15.000.000m$^2$ more collectors in the next period until 2017.

From renewable energy sources solar energy will receive the largest share. For that reason, billions of Euros are spent in the world on research, development and manufacture of equipment for the application of solar energy, both in the field of photovoltaic conversion and in the thermal conversion of solar radiation.

In the struggle for profit it is important to be first or at least one of the first. Each EU country has institutes, laboratories, schools and colleges for research and teaching on the application of solar energy. In China, and especially in India, there are several major research centers for the study of all possible ways of using solar energy in various fields of human activity. It is a bit strange that there are so many parallel studies in many places, but it just shows how important solar energy is for the future and that no country wants to remain inferior in its development and application. Energy security is in the first place in all long-term plans.

In addition to research in the field of thermal conversion and its implementation, a significant and inherent area is also storage of the received power. This is especially important in solar power plants that use thermal energy from the sun during the day. It is necessary to find ways to use the energy collected during the day at night. Research in the accumulation of heat is developed in two areas:

- Short-term energy storage (1 to 7 days)
- Seasonal storage of energy (from summer to winter)

Both areas are characterized by the research of materials from which tanks, heat insulation materials and materials that are used as heat accumulator are built. It is a broad research field from materials that will have maximum absorption power and minimum reflection, to the materials that provide self-cleaning collectors, corrosion protection, high efficiency fluid for energy transmission, high transmission glasses, concentrators and a lot of other components, materials and constructions. [2]

## The situation in Serbia

In the period from 1975 to 1990 in Serbia and Yugoslavia, thanks to the researcher and scientist Branko Lalović, the atmosphere of research, development and application of solar energy was created. At that time there were several manufacturers of solar collectors and ancillary equipment. A large number of systems for heating sanitation water were

constructed then, mostly in hotels on the Adriatic coast and in tourist areas. [3] Now, in Serbia there are two manufacturers of solar thermal collectors and several importers of complete systems. Installation of equipment for solar heating of sanitary water is based on individual urge of investors to do something that is natural and normal - to use what comes for free onto their roof, and what is completely clean. This is done no matter the cost or material gain from saving electricity. The second important group of solar energy users are our people who lived (or still live) on temporary work abroad, mostly in Germany and Austria. Due to their better material position they wanted to apply here what all normal people do in the countries where they have lived and worked. Overall in Serbia the application of solar energy for sanitary water or space heating is completely negligible. The same is the case in other areas of possible applications.

Compared with the plans of the European Union on the use of solar energy for space heating, we in Serbia are not doing anything now. Certain progress has been achieved in the field of energy efficiency, primarily thanks to the individual desire to reduce future costs for heating by improving the thermal insulation.

Unlike wind energy or hydropower to use solar energy for heating sanitary water or drying of agricultural products, no permissions or consents are needed. It means that there are no administrative or technical barriers to use solar energy, but there are other reasons that influence the current situation in Serbia:

- Ignorance about the use of renewable energy sources, about the situation and plans in Europe, about our future obligations and any beneficial aspects arising from their application in decision-making circles.
- Uninformed people about the possibilities of solar energy use, cost of equipment, energy and financial effects.
- The living standard of the population of Serbia is at a very low level compared to the price of the equipment that is the same as in the European Union.
- Low electricity price automatically leads to electricity not being consumed rationally. Compared to other energy sources, for consumers heating was best with electricity. It also showed this winter when the record consumption of over 150 million kWh per day was recorded.
- Production of domestic equipment is expensive because of import dependence in the procurement of materials and the small unformed market. Only one serious producer, due to low sales (80 collectors per year), cannot invest in manufacturing capacity equipment and become even more cost competitive compared to imported equipment.

## Recommendations

There are many ways to expedite and encourage activities in this area, and in the tradition of other developed countries most effects would be produced by:

- subsidizing the purchase of each solar system for heating sanitary water. Also, interest-free loans or tax exemption for the purchase of solar equipment would draw attention to this kind of energy savings and increase sales.
- subsidizing the manufacturing of solar equipment through loans or grants should help manufacturers to establish quality production and sales, with guaranteed prices unchanged during the period specified in the contract.

In the field of thermal conversion of solar radiation there are several possibilities for research and innovation. Development in this area is not so much connected with expensive equipment like in the case of photovoltaic conversion. It takes a lot of knowledge, experimentation, computer modeling and innovation in order to achieve noticeable and useful results. Areas such as concentrated radiation, hybrid systems (a combination of thermal and photovoltaic conversion), air collectors, integration of existing or new components in the building, the application in the distillation and desalting of water, pasteurization in the food industry, agricultural drying and heat storage are only one part of the programs that can be implemented in Serbia. [3]

In order to run these or similar development cycles universities and nongovernmental organizations need to be engaged to encourage students, graduate students, inventors and scientists through competitions, development workshops and research papers on fruitful activity whose results should be presented to producers. At university practical and creative work is inaccessible to most students, because their faculties do not organize any practice, and participation in the research and scientific work does not exist.

The latest decision that Serbia will set aside 200 million Euros this year for the recovery and development of science is an opportunity for at least 1% of funds to be spent on applied research in the field of renewable energy sources, with primary attention being paid to solar energy, geothermal energy and biomass. Ministry of Science and Technology in cooperation with the Ministry of Energy and Energy Efficiency Agency should continuously call tenders for research and demonstration projects with precisely given topics. Competitions should not be intended only for research institutions, but all project teams who have knowledge and ability to implement tasks. Past practice has shown that well-designed initiatives do not always produce results, as projects have been awarded on the basis of personal connections, funds have not been controlled, and the results have remained on paper as reports on most often unexecuted tasks. In this way, almost no domestic production has been initiated. If this practice changes and ensures that teams

participate in competitions with retired PhDs, engineers with a lot of practical experience, students and doctoral students who wish to practically improve and prove themselves, then we can expect fast, high-quality results. Of course that in this case connections with educational and research institutions are required and necessary, and it will establish itself, depending on the interests and capabilities.

## Conclusion

In order to intensify the use of solar power in Serbia it is necessary to create a favorable business climate for the development of domestic industries of solar equipment on the basis of its own research and development. Under current conditions it is possible to even in small series obtain equipment of suitable quality and at lower prices than imported equipment. Certification of domestic equipment remains one of the currently biggest unsolved problems in this regard.

It is necessary to set the goal that all needs to heat water to 80 ° C in the residential venues and industrial processes are met by using solar energy. This would encourage the construction industry to be seriously engaged in renewable energy.

It is also necessary to encourage development and innovation activities in the technology and manufacturing, which will lead to greater efficiency and lower prices in domestic production.

Certainly we must not ignore the continuous promotion of the use of solar energy, in which the media and non-governmental organizations can have a large role, which as recommendation can be applied to all other renewable energy sources.

## Literature

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