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SOLAR THERMAL ENERGY - STATE AND PROSPECTS OF DEVELOPMENT IN POLAND AND THE EUROPEAN UNION

Energy of solar radiation is most attractive, from the standpoint of the environment, source of renewable energy. Its use does not cause and side-effects or emissions of hazardous substances. This type of energy does not cause disturbances in natural resources, the environment, landscapes as well as plant and animal life; on the contrary, it is necessary for their proper functioning.

Analysis of fossil fuel resources and renewable sources of energy (solar, water, wind and bioenergy) shows that biggest opportunities can be found in solar energy. Good illustration of the size of resources for different types of energy is graphically presented in Figure 1.

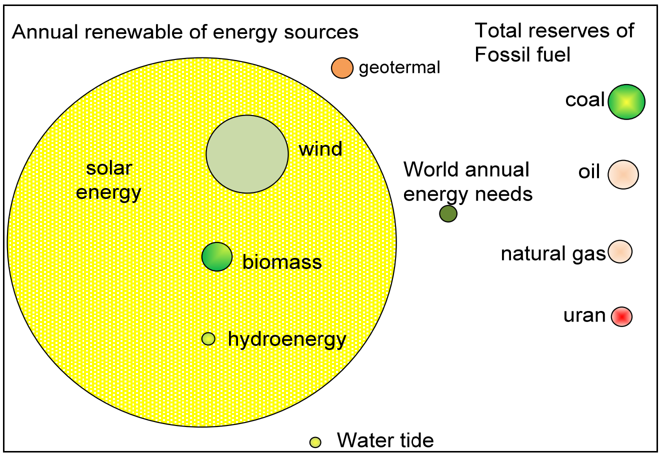
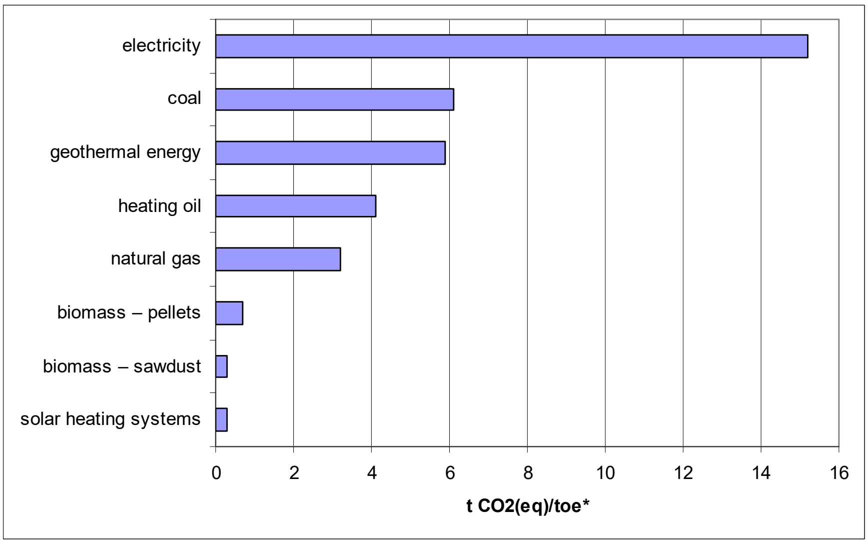


Fig. 1. Available resources of energy worldwide [1]

Figure 1 compares types and resources of energy. The circles on the left correspond to different types of renewable energy while on the right - fossil fuels. Size of a circle reflects the size of potential resources of individual types of energy. As can be observed from the figure, there are huge reserves which can be found in solar energy. The circle representing solar energy is much bigger than other circles for renewable energies (wind, biomass, water power, geothermal and tidal energy) and fossil fuels (coal, crude oil, natural gas, uranium). Furthermore, in central part of the figure a point whose size represents world annual demand for energy. Comparison of individual circles and their sizes provides a larger picture of energy resources. World energy demand, as compared to the enormous energy which is generated by the sun, points to its prospective role.

An important element of energy policies is also impact of each type of energy on the environment. Solar energy is particularly friendly and does not cause emissions, thus in Poland's and EU policies it should be treated as a high priority issue. Very interesting comparison of impact of individual types of energy in the study 'Vision of Development of Solar Energy in Poland with Plan of Action until 2020' [2]. Figure 2 illustrates maximal emissions of greenhouse gases which accompany production of heat from different production technologies. Despite imperfectness of these calculations, greenhouse gases emissions for the energy obtained from the sun is very small. This comparison shows unrivalled nature of solar energy.



*t CO_2(eq)/toe - equivalent of a tonne of carbon dioxide, emission of greenhouse gases during the process of energy production within a particular time.

Fig. 2. Maximal greenhouse emissions which accompany heat production using a variety of technologies in consideration of the whole installation lifecycle [2]

Energy of solar radiation is an energy which is easily accessible, however, it is characterized by low flux density and highly stochastic nature of occurrence. Source of solar radiation is thermonuclear reactions which occur in the Sun. The resultant energy is radiated to the space while its power amounts to $3.85 \cdot 10^{26}$ W. As results from the differences of sizes of the Earth and the Sun and the distance from each other, solar radiation with power of ca. $1.78 \cdot 10^{17}$ W reaches the atmosphere. A part of solar radiation reaching the Earth's surface is reflected while the other part is absorbed by the surface and the objects on the surface; another part of it is reemitted back to the atmosphere as a long-wave heat radiation [3, 4].

A fundamental factor which determines availability of solar radiation is the climate formed by geographical factors, such as:
– latitude,
– size of lands and seas,
– sea tides,
– height above sea level,
– land formation.

In order to determine opportunities of using solar radiation energy, the following fundamental parameters should be determined with their distribution in time:
– insolation (number of hours of sunshine),
– irradiation of horizontal and sloped surface,
– structure of solar radiation (share of components in global radiation).

Knowing the values and distribution of radiation in time, it is possible to determine coherence of solar source for predictable time period and a method of use of energy.

In order for solar radiation energy to be directly used, the following methods of conversion of this energy into effective energy can be listed:
- photothermal conversion, which results in transformation of solar radiation energy into heat energy,
- photovoltaic conversion, also referred to as a photoelectric one, where a transformation of solar radiation energy into electricity occurs through application of suitable methods and equipment,
- photochemical conversion, in the case of which a transformation of solar radiation energy into chemical energy or other forms of energy connected with chemical processes occurs.

These conversions can occur simultaneously or separately. In practice, photothermal and photovoltaic conversions are employed and, with current stage of technological advances, the most typical methods are solar collectors to convert solar energy into effective heat. In further considerations, the focus will be on photothermal conversion, however, it is remarkable that recent achievements in improvement of efficiency of solar energy conversion into electricity open up new prospects for dynamic development of photovoltaic technologies. Both methods of conversion in Europe and Poland are increasingly more popular.

Solar collectors, which form elements of active installation systems, are developed in order to maximally use energy of solar radiation. Solar radiation, when reaching a collector, is absorbed by the collectors' surface and conversed into heat energy. This energy is used to heat up a medium. The medium can be water, other liquids or air to distribute heat to installation.

Current solar collector market is one of the fastest developing markets of renewable energy in Europe and worldwide. Level of installations of new collectors, expressed in surface-related figures for individual year is illustrated by Figure 3.

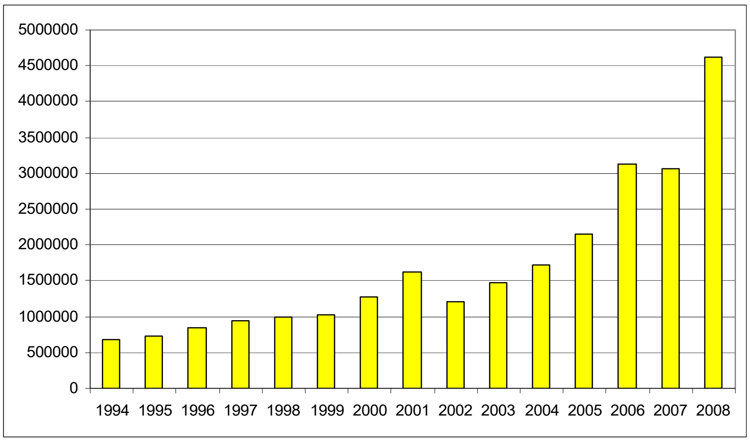


Fig. 3. Evolution of annually installed surfaces in the European Union since 1994 in m^2, [5, 6]

As results from the figure, considerable rise in use of new solar collectors throughout the last five years, was observed, at the level of 30% on average. The surface of solar collectors of 4 626 000 m^2 installed in 2008 in the European Union countries corresponds to 3 237.5 MW_{th} (thermal megawatt)[1], which constitutes a rise by ca. 50% in relation to 2007.

There are a number of constructional solutions for collectors although their practical use in the European market can be observed for:

- flat-plate solar collectors,
- vacuum tube solar collectors,
- unglazed (or pool) solar collectors.

Percentage share of individual types of collectors in the EU market is illustrated in Figure 4.

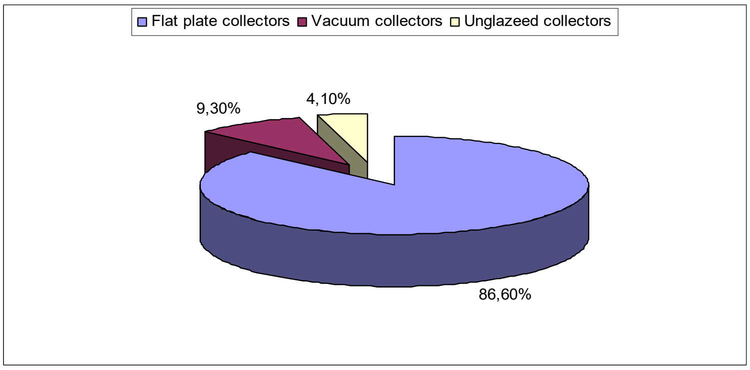


Fig. 4. Breakdown by technology of the 2008 solar thermal market in the European Union in %, [5, 6]

[1] 0.7 kW_{th} corresponds to 1m^2 of collector surface, according to the European Solar Thermal Industry Federation [ESTIF]

As results from Figure 4, with installation of new collectors at the level of 4 626 400 m^2 in 2008, 86.6% was taken by flat plate collectors, which dominate in the EU market. Insignificant contribution of 9.3% was found for vacuum collectors and 4.1% for unglazed collectors used most often in the systems for heating of water in swimming pools.

Shares of individual countries of the EU in use of installations of new solar collectors in 2008 is graphically represented by Figure 5. Huge differentiation, resulting from the size of the countries, insolation, social and economic development and policies for support of solar energy application. Highest surface area of 1 920 000 m^2 was installed in 2008 in Germany. Poland, with its surface area of collectors of 129 632 m^2 is on the seventh place among all the EU member states.

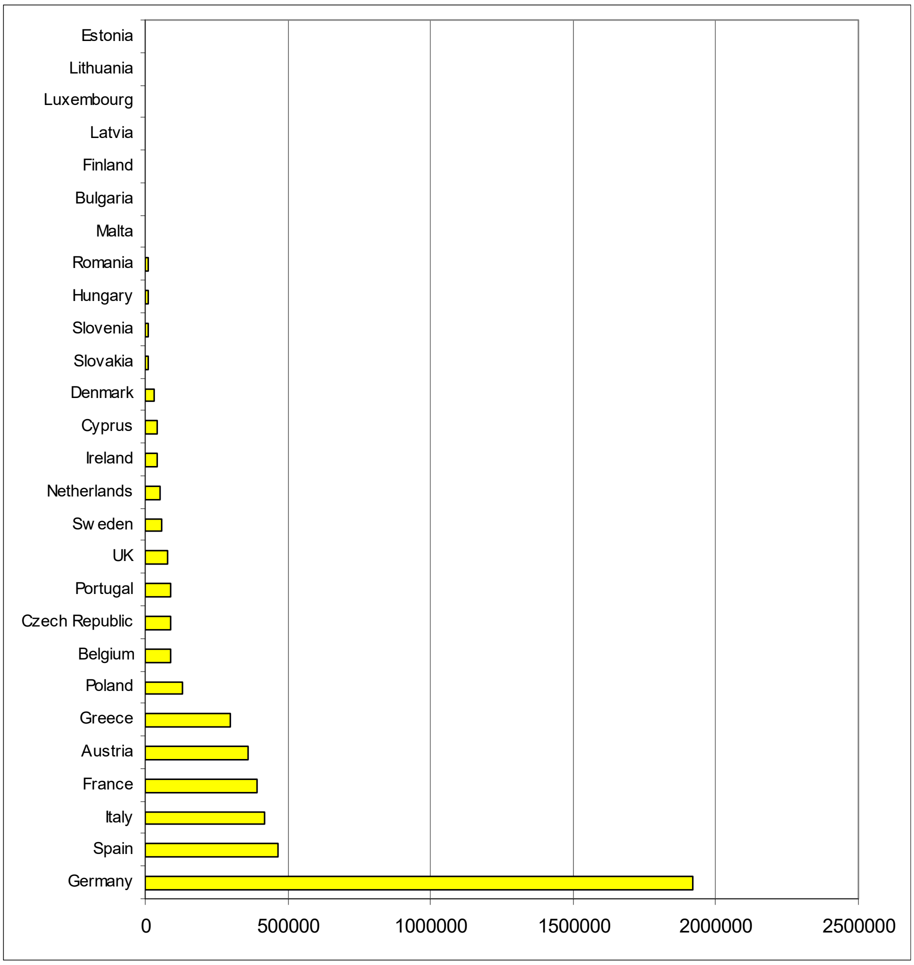


Fig. 5. Annual installed surfaces in 2008 in the European Union countries per type of collector in m^2, [6]

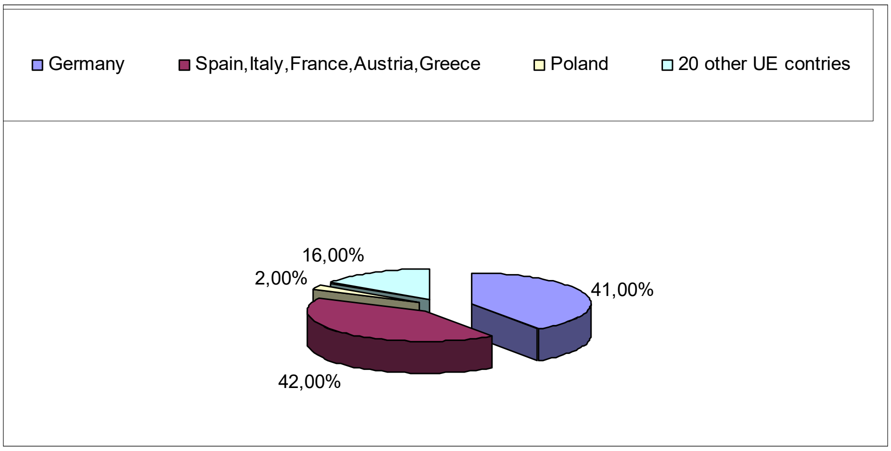


Fig. 6. Percentage share of European Union in installed for New solar collectors in 2008 in %, [5, 6]

This is confirmed by a percentage share of each EU country in 2008, illustrated in Figure 6. Germany, with 41% contribution of 1 920 000 m^2 is in the lead. Next group, i.e., Spain, Italy, France, Austria and Greece in total, installed in 2008 the collectors with total surface area comparable with Germany, with share of 42%. Share of Poland, with 129 632 m^2 in 2008, amounted to 2%. For assessment of use of solar energy, it is more interesting and measurable to employ a value of surface of solar collectors per capita and corresponding power equivalent for individual countries of the EU illustrated in Figure 7.

As results from Figure 7, the highest index of 843.0 m^2 per 1000 inhabitants can be observed for Cyprus, and the corresponding power index amounts to 590.1 kW_{th}. Average value of power index for collectors in the EU in total in 2008 amounted to 40.2 kW_{th} per 1000 inhabitants, however, in Poland this figures were at the level of 6.7 kW_{th}/1000 inhabitants. The European Union, setting new quantity goals for renewable energy sector development until 2020, also assumes that this index will rise up to 350÷700 kWth per 1000 inhabitants. These prospects for development of the market result from development and improvement in technologies of production of absorbers and solar collectors. Development of this technology opens up opportunities for innovation and increasingly wider implementation of industrial methods, thus use of benefits of scale. Market of solar collectors does not depend, as could be expected, on insolation conditions but on awareness of the society and mechanisms of support in each country.

Polish market of solar collectors is typically dominated by flat plate solar liquid collectors, whereas air vacuum solar collectors and unglazed solar collectors are used relatively rarely.

Evolution of development of use of solar collectors in Poland in present decade is presented in Figure 8. As results from the data [5-7] and Figure 5, the collectors with the surface area of 129 632 m^2 with corresponding power of 90 MW$_{th}$ were installed in 2008 in Poland, whereas in 2007, these values amounted to 68 147 m^2 and 47.7 MW$_{th}$, respectively, which means 90% rise. The rate of installation of new collectors for Poland in the last year is higher than for the EU in total.

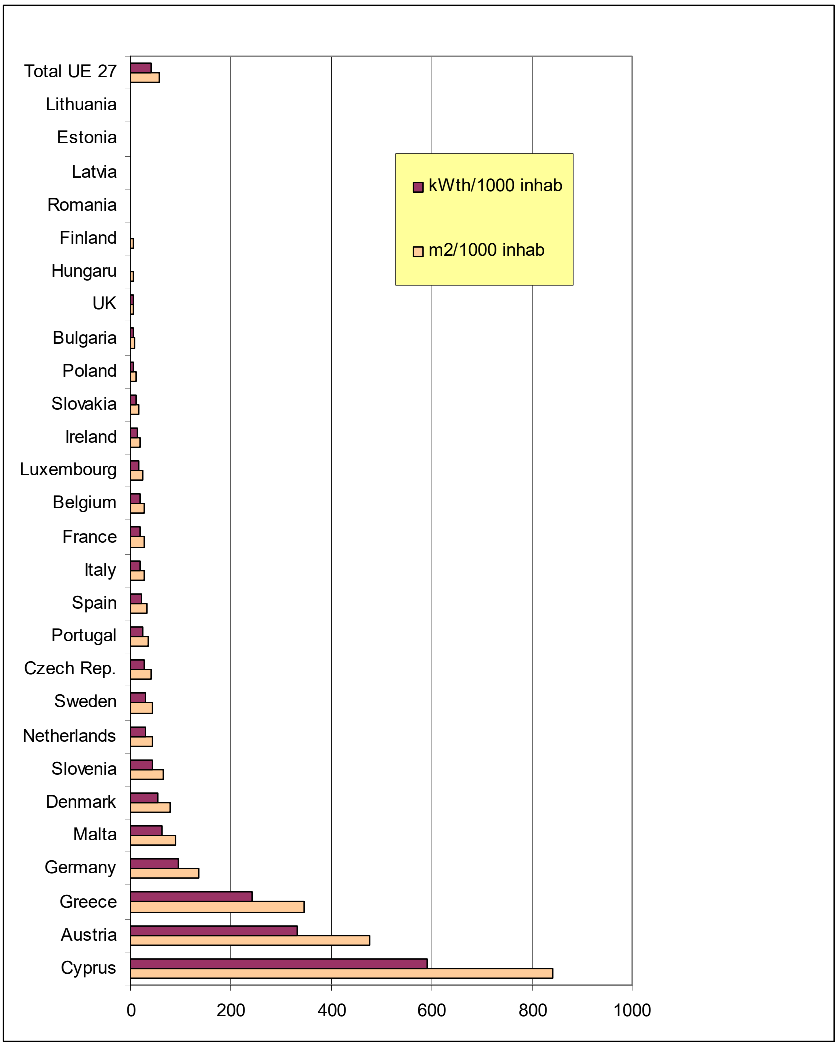


Fig. 7. Solar thermal capacities in operation per 1000 capita in m^2/1000 inhab. and kW$_{th}$/1000 inhab. in 2008, [8,14]

Role, which is played by the solar energy in heat production in Poland from different renewable sources in 2001-2008 is shown in Figure 9. Volume of produced heat from solar collectors is much more higher than produced from biogas, biomass and geothermal sources. The tendency shown in Figure 9 prognoses meaningful share of solar energy in the nearest perspective.

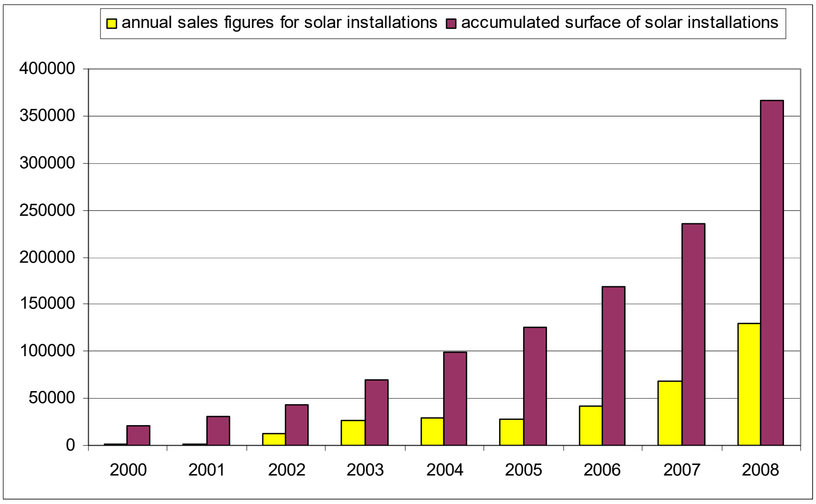


Fig. 8. Evolution of solar collector surface installed in Poland in 2000-2008 expressed in m^2, [5-7]

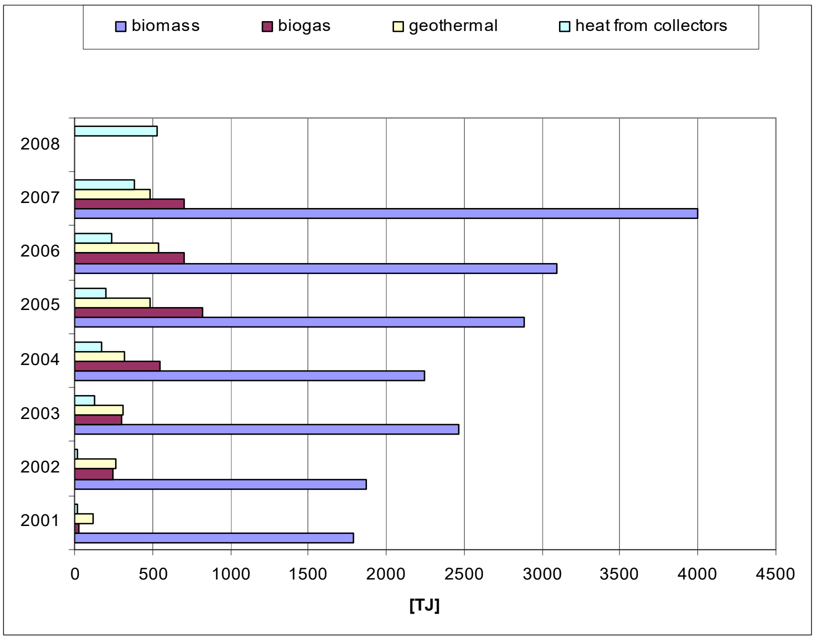


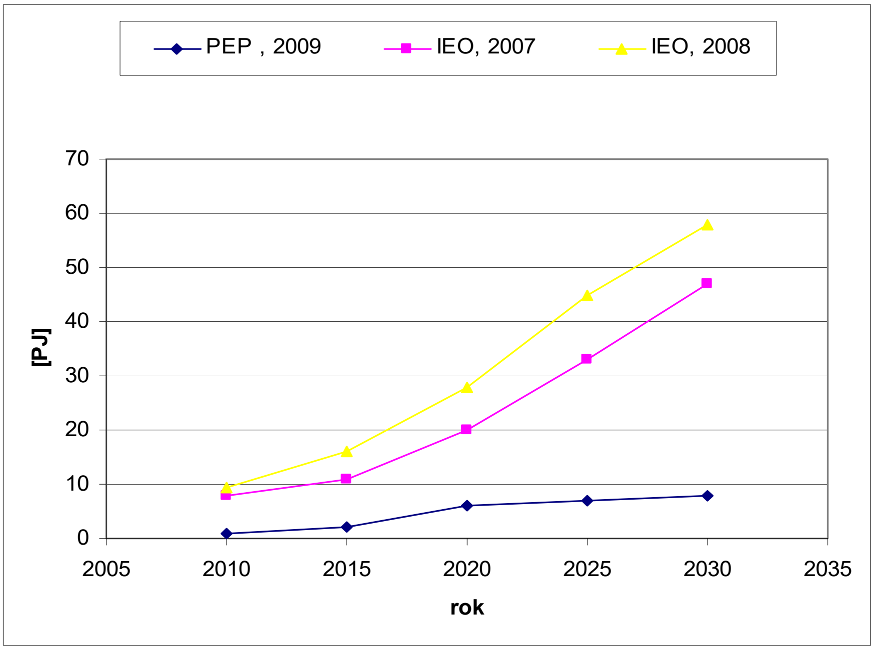
Fig. 9. Heat production from renewable sources in Poland during 2001-2008 [3]

At present, one of the most important elements of energy policies in the European Union is to improve energy efficiency and to increase share of renewable sources of energy in its consumption in total. A reflection of realization of this policy is the energy/climate package and 3x20 plan, whose basic commitments were formulated in the form of the following resolutions:

- to increase, until 2020, the use of energy from renewable resources - by **20 percent**,
- to improve energy use efficiency - also by **20 percent**,
- reduction of greenhouse gases emissions - also by **20 percent**.

The EU's energy - climate package of 3 x 20%, particularly its new directive [8, 9] on promotion of use of renewable resources of energy, provides perfect conditions for fast development of new technologies of renewable energy. The directive also promotes, on the basis of the same principles, green heat as well as green electricity and biofuels, while production of heat using solar energy is one of the most competitive technologies of renewable energy.

The Council of Ministers of the Republic of Poland adopted, in 10 November 2009, ***Energy Policy of Poland until 2030***. The document, prepared by the Ministry of Economy, contains long-term strategy of development in energy sector, forecast for demand for fuels and energy and plan of implementation activities until 2012. Sadly, the adopted program assumes insignificant share of solar energy in energy demand at the level of 1.2% in 2020 and not much more in 2030, which is presented in Figure 10 [9]. Other documents prepared for the government assume opportunities to satisfy much bigger demand [2, 10]. These forecasts, presented in Figure 10, provide much greater opportunities while their realization depends on the policies and tools for support in Polish government.



PEP, 2009 - Energy Policy for Poland until 2030 [9], IEO, 2007 - Expertise prepared by EC REC IEO for the Ministry of Economy [2], IEO, 2008 - report by IEO for Greenpeace [10]

Fig. 10. Forecast of development of solar energy [13]

Realization of the forecasts, even less ambitious, will require versatile actions, such as:

- extending a group of beneficiaries who take advantage of ecological funds and tax reliefs over domestic customers in particular,
- support for operators of central heating systems through granting them 'green' certificates of origin,
- implementation of tax reliefs for solar collectors sold in Poland,
- national-wide activities towards promotion and education for prospective customers for solar energy.

Increasing demand for heat and cooling will cause development of solar energy market. Development and popularization of use of the Sun will result in cost reduction, providing also benefits for the whole economy and population. A particular advantage of solar energy heating systems is their positive impact on the environment, resulting from reduction of greenhouse gases emitted to the atmosphere.

Furthermore, solar energy sector is characterized, as compared to other renewable sources, by relatively high energy efficiency per surface area. Popularization of the use of solar energy will also advantageously impact on labour market through creation of new workplaces.

Development of solar energy sector is a serious challenge for ecological funds in Poland and the EU as well as for organizations and institution for support of this sector.

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Abstract

This study presents opportunities and potential of solar energy and tendencies of its use. The EU climate package of ‘3 x 20%’, and a new directive of EU about promotion of renewable sources of energy create perfect conditions for fast development of modern technologies in solar energy sector. Evolution of use of solar energy in Poland points to huge potential which cannot be neglected.

Streszczenie

W pracy przedstawiono możliwości i potencjał energii Słońca oraz tendencje w jej wykorzystaniu. Pakiet klimatyczno-energetyczny UE „3 x 20%”, a w szczególności nowa dyrektywa UE o promocji stosowania odnawialnych źródeł energii stwarzają doskonałe warunki do szybkiego rozwoju nowoczesnych technologii energetyki słonecznej. Ewolucja wykorzystania energii Słońca w Polsce pokazuje jej ogromny potencjał, który winien znaleźć zastosowanie w szerszym zakresie.