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INVESTMENT IN SOLAR COLLECTORS ON THE EXAMPLE OF A CITY AND COMMUNE BŁAŻOWA

Due to depleting natural resources and increasing costs of their extraction, alternative energy sources are becoming an import ant branch of energy. Their impact on environmental pollution is much lower than with conventional energy sources, or if you consider solar energy zero. Currently, many programs are subsidizing the costs of assembly and devices using renewable power sources, the beneficiaries of which are residents of municipalities participating in projects that are largely financed by the European Union. Solar collectors are devices used to heat water for everyday use in homes and farms. Thanks to adequate sunlight they are able to provide comfortable medium temperature conditions for most of the year. This significantly reduces bills for natural gas or electricity – depending on the type of water heater. Collectors are divided into 3 types: flat, vacuum and focusing. Their heat conducting medium may be liquid or gas. Photovoltaic devices, solar collectors and biomass stoves were used in the commune and the city of Błażowa. Focusing on collectors, it can be seen that the flat collectors have been selected, which have a good price-performance ratio and the energy obtained. 210 households benefited from the co-financing program. Most people decided to install collectors on residential buildings because their own contribution depended on the location of the devices – 8% VAT for mixing buildings and 23% VAT for farm buildings. The cost of the set on a residential building depended on the power and ranged from 2,488.00 [zł] to 3,131.60 [zł], which with a net price without co-financing of respectively 8600,00 [zł] to 10,770.00 [zł] gives a very large saving. The effect of the investment is about 75% energy saving, which in a few years allows you to recover the money invested in collectors.

Keywords: solar energy, flat collector, co-financing, alternative energy sources

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1. Alternative sources of energy

1.1. Introduction

Alternative energy sources are now competing with conventional sources. In the world, due to the growing energy demand and environmental policy, traditional ways of obtaining fossil fuels are becoming more expensive and their extraction due to limited resources is becoming more and more expensive. Therefore, investing in energy from other sources is becoming more and more profitable. Alternative sources do not pollute air and water with by-products as much as conventional sources. It is the more advantageous solution that to a lesser extent contributes to increasing the greenhouse effect. In the case of the renewable source chosen in the publication, which is solar radiation, no environmental pollution occurs during energy production.

In Poland, despite the fact that we are lagging behind in terms of the amount and use of renewable energy sources in terms of the western European Union countries, there has been an upward trend for several years, mainly thanks to funding programs, including photovoltaic installations, solar collectors and biomass furnaces such as "Czyste powietrze", "BOCIAN"– distributed renewable energy sources" and other numerous EU subsidies.

In the publication, we take into account the changes in the Commune and the City of the Błażowa, which occurred as a result of the project "Odnawialne Źródła Energii w Mieście Przeworsku i Gminie Błażowa", which was and is co-financed by the European Union under the Regional Operational Program of the Podkarpackie Voivodeship for 2014–2020.

1.2. The Sun is a source of energy

On a global scale, the sum of annual average long-term insolation ranges from 800 [kWh/m^2] in countries in the Arctic zone to about [2,200 kWh/m^2] in equatorial regions. In Poland, due to its location in the temperate zone, it is about 1,100 [kWh/m^2]. In the summer it is about 75% radiated and in the winter about 25% of solar energy [1]. It gives the possibility of effective use of solar energy in 100% in summer and in winter to partially cover energy demand in households [3,5].

The most prominent area with the highest intensity of solar radiation is the central and eastern part of the Lubelskie Voivodeship. The largest solar power plants in the country are located there and further solar farms are planned to be built. The least sunshine is concentrated in the region of the central Śląskie Voivodship, in the lake district of the Zachodniopomorskie, Warmińsko-Mazurskie Voivodships and in the southern part of the Dolnośląskie and Podkarpackie Voivodships (Fig. 1) [4].

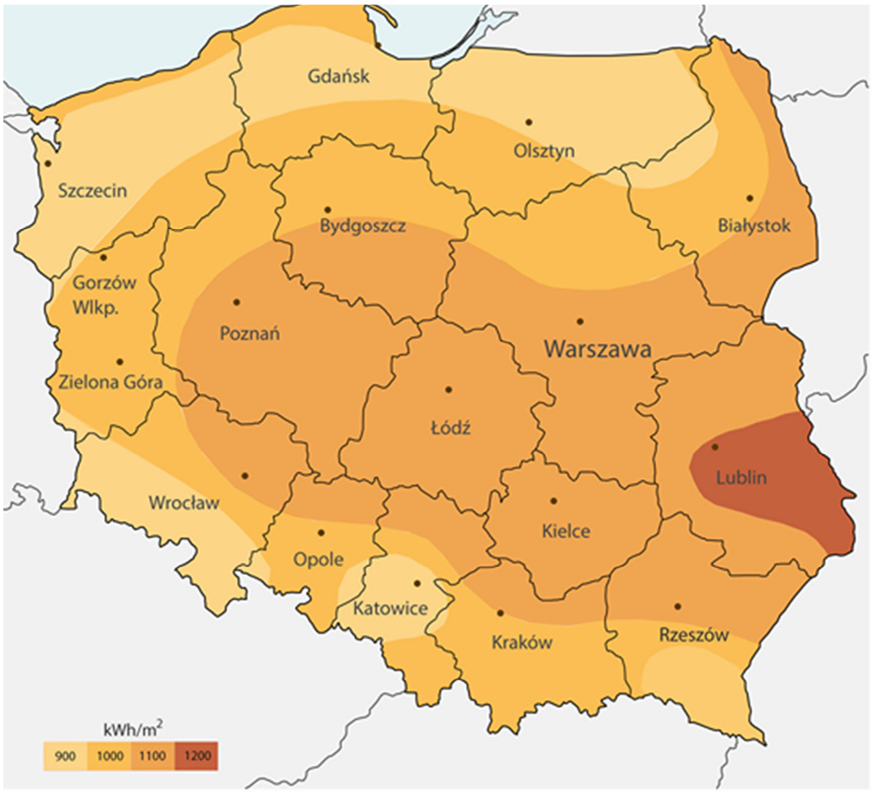

Fig. 1. Map of the Sun of annual average long-term insolation In Poland [4]. Source: own study

The year average value of the insolation in the Podkarpackie Voivodship is over 1,000 [kWh/m^2]. The difference between the highest and lowest annual value is about 100 [kWh/m^2]. This is a sign that in the Podkarpackie it is advisable to use technologies aimed at using solar energy to support the production of electricity and water heating. The Rzeszów poviat performs best among all (Fig. 2), but despite this, its potential is not enough for the Sun to be the only source of both heat and electricity. Nevertheless, the effects of using both photovoltaic installations and solar collectors seem to have measurable benefits for the user [4].

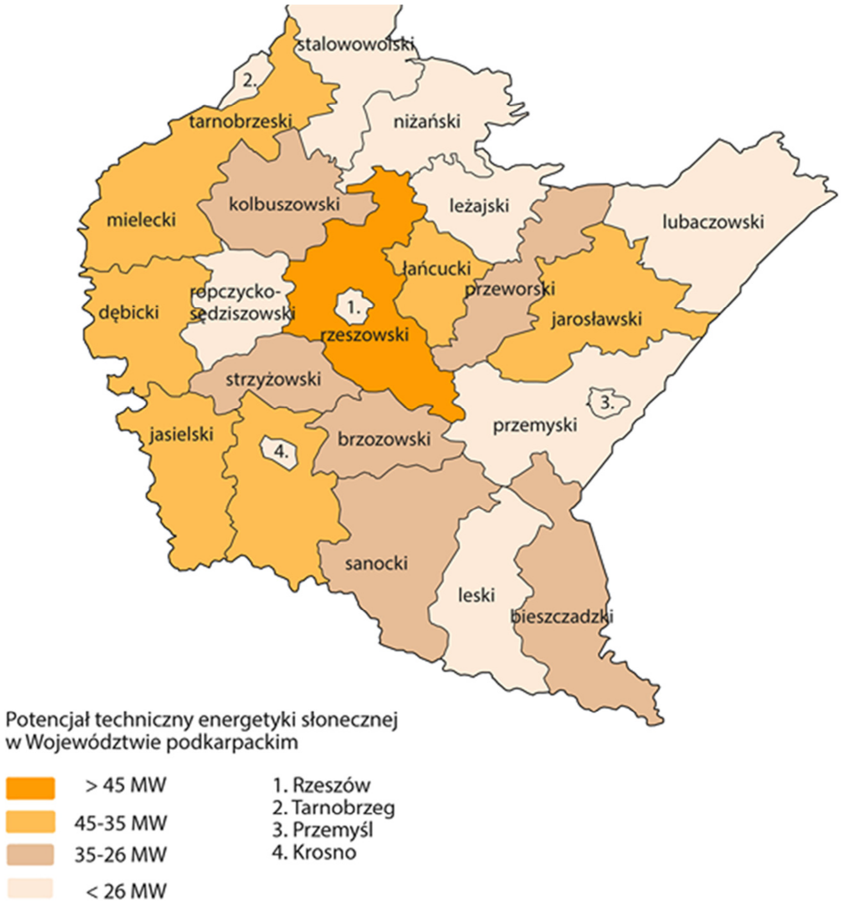

Fig. 2. Map of technical potential of solar energy in the Podkarpackie. Source: own study

2. Solar collectors

2.1. Solar collectors – division and types

Solar collectors are devices designed to convert energy obtained from solar radiation into thermal energy. This transformation largely depends on the technology and material from which the collector was created, as well as the specifics of its construction [2].

The working factors in the devices are liquid or gas, hence the collectors are divided into gas and liquid. The main type used in Poland are devices with a liquid medium, which are divided into 3 types: flat, vacuum and focusing. The definition of this division is the density of solar radiation that falls on the absorbing part - the cheapest and the simplest option is the absorbing plate, which is placed on the insulating-anti-heat surface. Solar radiation is partially transmitted and absorbed. Only the absorbed portion of radiation is used [3].

Focusing collectors rely on the use of a lens. Which reflects solar radiation directing it to a cable, usually copper, with a factor. This phenomenon consists in directing as much radiation as possible to the piping using a mirror [4].

Vacuum collectors are double-walled glass pipes. Between the walls, a vacuum is applied and welded like in a thermos, making it a great radiation-permeable insulation. There are refrigerant lines in the glass tubes. The components prepared in this way are mounted in the frame and the device is ready for operation. They are used wherever it is not possible to use flat collectors due to the possibility of rotation of each element and thus optimization of radiation capture. However, due to the use of slightly higher accuracy and precision of the elements, these collectors are much more expensive than flat ones, so they are mostly not subsidized [1].

Flat collectors are the simplest solution for providing domestic hot water through solar energy. The construction of such a collector is mainly copper piping, which is mounted in frames on thermal insulation. Styrofoam can meet thermal insulation although it is usually mineral wool. The absorber is usually a plate made of aluminum, less often copper or steel. An absorption layer is applied on top of the plate, it can be ordinary or selective. The usual form is usually dark, matte paint or varnish. The selective layer is a more expensive, more expensive, but also more durable and more effective solution, it consists of superimposed galvanized black chrome coatings that are applied to the nickel layer. The device built in this way is very light and has a low heat capacity, the time constant is about a dozen or so seconds. It causes that the collector reacts quickly to changes in radiation. An ordinary layer has an emissivity practically equal to absorption, while a selective coating has a high absorption and low emissivity, which makes it a very beneficial solution. The coil connected to the absorption layer, in which the heat transfer medium is located, receives energy from the coating and transfers it to the condenser. Joining panels consists of plasma welding or ultrasonic joining. The pipes are connected in parallel or coil. The collector housing is usually made of aluminum sheet, often painted, above the absorber there is a transparent coating, ensuring the flow of radiation, it is made of plastic or solar glass. The entire enclosure must be highly airtight. The insulation layer is located on the bottom of the housing, the collector must have ventilation holes if there is a risk of getting moisture. The seal between the cover and the casing should be as tight as possible, because the lifetime of the collector depends on it, mainly polyurethane silicone is used as the sealant [4-8].

Flat collectors with the installation used are the most often subsidized form due to the simplicity of construction and low cost of materials from which the devices are made. They were selected for co-financing in the project "Odnawialne Źródła Energii w Mieście Przeworsku i Gminie Błażowa".

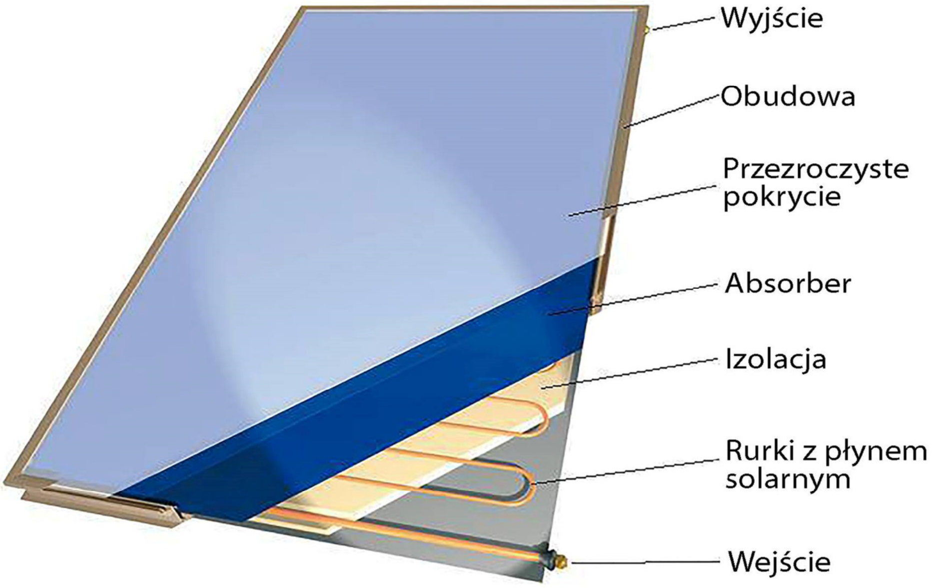

Fig. 3. Construction of flat collector. Source: own study

2.2. Collector efficiency

The efficiency of the collectors depends mainly on the quality of the closure of the air area, where the system is responsible for receiving heat from the pipe, no ventilation of the interior of this space should be allowed. The second most important thing for efficiency is the precision of taking over the heat transferred to the working medium. The efficiency of the collectors can be assessed on the basis of the efficiency chart and the stagnation of the collector temperature (Fig. 4) [3].

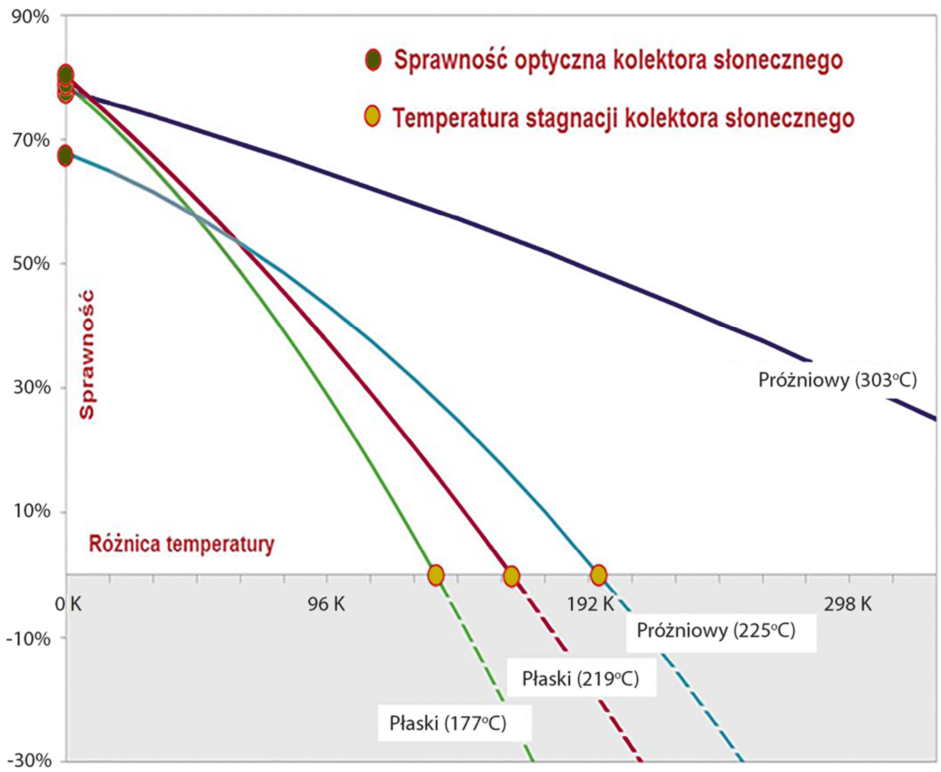

Fig. 4. Graph of efficiency characteristics and collector stagnation [3]. Source: own study

3. The use of solar collectors in The Commune and The City of Błażowa

Flat collectors were used in the Błażowa commune. A total of 210 solar collector installations installed there, available in three sets. Co-financing of delivery and assembly costs depended on the location of the collectors and the composition of the set. Most beneficiaries decided on the installation mounted on a residential building due to significantly lower costs including 8% VAT. Leaving a residential building or installing solar collectors on an outbuilding generated a higher cost because 23% VAT was included. Only three beneficiaries declared to place the installation on a site other than a residential building, two placed the installation on business buildings, while one was placed on the ground. These people decided on set 3.

Fig. 5. Solar collectors on the facade, Błażowa. Source: own study

Fig. 6. Solar panels and collectors, Błażowa Dolna. Source: own study

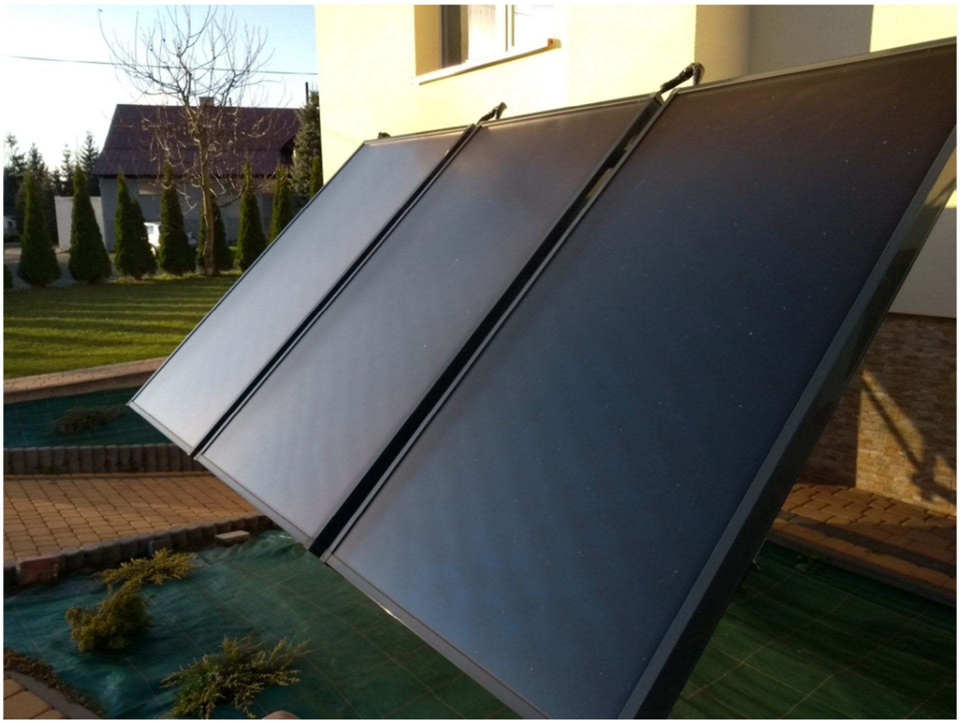

Fig. 7. Solar collectors founded on the ground, Białka. Source: own study

In accordance with the Table 1, the following calculations were made to determine the amount of funding. Support for the partner project " Odnawialne Źródła Energii w Mieście Przeworsku i Gminie Błażowa " was not particularly dependent on the size of the installation. The net own contribution is about 21%. The more solar panels were used, the greater funding was obtained by the beneficiary, but the difference is small, as shown in the Table 2.

Table 1. Delivery and assembly costs

No.	Set of collectors	Pcs.	Co-financing depends on the location of the set		
			Net [zł]	On a residential building	Outsite the residential building
				Beneficiar's own contribution at 8% VAT (with VAT tax) [zł]	Beneficiar's own contribution at 23% VAT (with VAT tax) [zł]
1	2/200	99	8,600.00	2,488.00	-
2	3/300	106	9,680.00	2,804.40	4,256.40
3	4/400	5	10,770.00	3,131.60	-

Table 2. List of costs for collector sets instaled in the comune of Błażowa

No.	Set of collectors	List of costs			
		8% VAT	23% VAT	Costs of delivery and assembly (net)	Own contribution (net) [%]
1	2/200	688.00	-	1,800.00	20.93
2	3/300	774.40	2,226.40	2,030.00	20.97
3	4/400	861.60	-	2,270.00	21.08

Based on the information in the Table 3 and the information obtained from users, we get approximate annual savings for the farm where three panels are mounted. Manufacturer's data provide guaranteed annual yield from the collector min. 525 [kWh / m^3], with three panels of 7.53 [m^2], we obtain 3,953.25 [kWh / m^3 * year]. By converting the kWh value into units of fuel and electricity that the boiler needs and multiplying it by the unit price of fuel / energy, we get predictable annual savings.

Table 3. List of costs for collector sets installed in the commune of Błażowa

Specification	Annual heat saving for DHW	Fuel/energy saving	Fuel/energy unit purchase price	Costs savings of the first year
Natural gas	3,953.25 kWh/year	413.70 m^3/year	2.16 zł/m^3	893.59 zł/year
Heating oil		366.79 dm^3/year	3.35 zł/dm^3	1,228.74 zł/year
Electric boiler		2,925.68 kWh/year	0.55 zł/kWh	1,609.12 zł/year

Most solar installations were installed in the city of Błażowa which results from a better communication of information to the residents.

Table 4. List of installations, broken down into individual towns in the Błażowa commune

No.	Place	Number of installed collectors			
		On a residential buildings	On a farm buildings	On ground	Together
1	Białka	12	-	1	13
2	Błażowa	44	2	-	46
3	Błażowa Dolna	22	-	-	22
5	Futoma	18	-	-	18
6	Kąkolówka	32	-	-	32
7	Lecka	13	-	-	13
8	Nowy Borek	29	-	-	29
9	Piątkowa	20	-	-	20
				Σ	**210**

4. Conclusions

Based on the tables in which annual savings are given, it can easily be calculated that due to the low own contribution it can be recovered depending on the type of fuel / energy within 2 to 4 years. After this period, subsequent years of using solar collectors will bring savings depending on insolation and efficiency of devices. The investment in renewable energy sources on the example of the Commune and City of Błażowa clearly shows the profitability of buying solar collectors. Thanks to the efforts of the commune authorities, the inhabitants paid practically only the costs of assembly and delivery (with VAT tax). To sum up, it is worth using programs supporting the creation of alternative energy sources, not only for environmental but also for purely economic reasons.

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