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## **PROJECTED COST AND PROFITABILITY OF INVESTMENT IN PHOTOVOLTAIC INSTALLATIONS ON AN AGRITOURISM FARM**

### ***PLANOWANE KOSZTY I OPLACALNOŚĆ INWESTYCJI FOTOWOLTAICZNYCH W GOSPODARSTWIE AGROTURYSTYCZNYM***

**Key words:** renewable energy sources, electrical energy, photovoltaics, rural areas, agritourism farms

*Słowa kluczowe:* odnawialne źródła energii, energia elektryczna, fotowoltaika, obszary wiejskie, gospodarstwa agroturystyczne

*JEL codes:* Q220, Q12, Q13

**Abstract.** The article aims to present projected cost and profitability of investment in photovoltaic installations on an agritourism farm. Special attention is drawn to economic efficiency of a system of photovoltaic modules installed on an agritourism farm hosting a four-member tourist group and using a photovoltaic system having a capacity of 5 kWp. It has also been assumed that the whole amount of electricity produced is used on the agritourism farm. The analysis results have taken into consideration the assumption estimating the use of energy at the level of about 5,000 kWh per year. The annual energy cost estimation is PLN 2,750 (5,000 kWh x PLN 0.55).

## **Introduction**

Production of energy from renewable sources depends on changeable atmospheric conditions. Therefore, in the periods of intensive production, which do not always correspond to high consumer demand, difficulties with the use of excess power may occur. The most common systems are based on the supply of energy from non-renewable resources in the periods of insufficient production of energy from renewable sources and systems composed of a few renewable sources supplementing each other and providing different amount of energy at different periods throughout a year. Renewable energy sources make it possible to increase the efficiency of needs satisfaction by better adjustment of the type, amount and quality of energy produced to the changeable demand for it on an agritourism farm. In practice, also daily, less often seasonal, storage of energy in batteries or thermal storage facilities is applied [Jankowska 2008]. Planning renewable energy acquisition on an agritourism farm is based on identification of real energy needs that takes into consideration daily, seasonal and yearly fluctuations as well as possibilities of satisfying them by properly selected renewable resources.

Renewable sources of energy [K. Roman 2016] constitute an alternative to traditional primary non-renewable energy carriers. Their resources replenish in the course of natural processes, which practically allows for treating them as inexhaustible. Moreover, obtaining energy from these sources, in comparison with traditional ones, is more environmentally friendly. The use of photovoltaic panels on an agritourism farm is one of the significant components of sustainable development, which provides measurable economic, ecological and social effects [M. Roman 2016]. Renewable energy sources on agritourism farms may play an important role in the development of tourist facilities.

## Research aim, scope and methodology

The article aims to present the projected cost and profitability of investment in photovoltaic installations on an agritourism farm. Data found in literature and authors' own calculations have been used to that end.

### Photovoltaic panels on an agritourism farm

A photovoltaic cell is an electrical device that converts sunlight into electrical energy. The energy produced in the form of direct current is converted into alternating current with the use of inverters. A photovoltaic cell has two layers: positive charge one (+) and negative charge one (-). When sunlight reaches a cell, voltage is created between the layers. A single cell does not usually exceed the voltage of 0.5 V and the power of 2 W. Bigger voltage can be obtained by assembling cells into modules. Solar panels can be bought countrywide. Table 1 presents how many of the 339 companies listed by the Internet service Business Navigator operate in this market in particular provinces.

The assembly of a certain number of photovoltaic cells results in building a module providing the voltage of 12 V and the power of up to 80 W. But panels with the voltage of 24 V and the power over 200 W are more and more often offered. Obtaining voltage equivalent to mains electricity (230 V) requires the use of an inverter of an appropriate size converting direct current of 12 V into alternating current of mains voltage equalling 230 V. Optimal conditions for obtaining voltage directly depend on the type of cells and whether a user follows the producer's guidelines. The cell quality determines its lifespan, however, the average lifetime is estimated to be 30 years. A photovoltaic system contains the following elements:

- a photovoltaic module,
- an inverter,
- a fastening system,
- joining accessories.

Photovoltaic panels may be installed on agritourism farms. Investment in a photovoltaic installation outside a building contributes to the reduction of expenditure on electricity to a considerable extent and balancing a surplus of produced energy that can be transferred to the national grid in a six-month period. The amended energy law abolishes the obligation to register business activity by an owner of electricity production facility not exceeding a capacity of 40 kW. An installation is joined to the grid after its registration in an energy distribution company and that company covers the cost. Accordingly, under Article 41 of the *Act on renewable sources of energy* [JL 1997, no. 54, item 348, art. 41], it is possible to net-meter surpluses of energy in six-month periods, which means that electricity

Table 1. Number of registered companies involved in trade in photovoltaic panels by provinces

*Tabela 1. Liczba zarejestrowanych firm działających na rynku paneli fotowoltaicznych dla poszczególnych województw*

| Province/<br>Województwo | Number of<br>companies operating<br>in photovoltaic<br>panels market/<br><i>Liczba firm<br/>działających<br/>na rynku paneli<br/>fotowoltaicznych</i> |
|--------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------|
| Dolny Śląsk              | 35                                                                                                                                                    |
| Kujawsko-pomorskie       | 14                                                                                                                                                    |
| Lubelskie                | 12                                                                                                                                                    |
| Lubuskie                 | 5                                                                                                                                                     |
| Łódzkie                  | 29                                                                                                                                                    |
| Małopolskie              | 43                                                                                                                                                    |
| Mazowieckie              | 41                                                                                                                                                    |
| Opole                    | 12                                                                                                                                                    |
| Podkarpackie             | 21                                                                                                                                                    |
| Podlaskie                | 8                                                                                                                                                     |
| Pomorskie                | 24                                                                                                                                                    |
| Śląskie                  | 42                                                                                                                                                    |
| Świętokrzyskie           | 6                                                                                                                                                     |
| Warmińsko-mazurskie      | 10                                                                                                                                                    |
| Wielkopolskie            | 19                                                                                                                                                    |
| Zachodniopomorskie       | 18                                                                                                                                                    |

Source/Źródło: [<http://www.baza-firm.com.pl>, 7.12.2016]

can be acquired from the network at night or in periods of low on-site production level and excess energy in periods of high production level can be sent into the grid. The Act on renewable sources of energy has considerable influence on energy production by prosumers because it stipulates e.g.:

- obligatory purchase of electricity from a newly-built renewable energy sources facility with a capacity of 10 kW at a guaranteed price over a period of 15 years;
- obligatory purchase of unused electrical energy resources at a full (100%) average selling price binding in the competitive market in the previous quarter;
- net-metering based on a calculation of how much energy is consumed and how much excess energy is sent back into the electric utility grid in six-month periods.

New principles of supporting prosumers' electrical energy systems entered into force on 1 January 2016. The price depends on the fuel used and the type of facility. Approximately, the gross price of energy produced in facilities having a capacity of 7-10 kWp is ca. 5,700 PLN/kWp and in 3 kWp systems the value rises to 7,000 PLN/kWp. Production of energy from renewable sources may be financed on conditions proposed by NFOŚiGW [the National Fund for Environmental Protection and Water Management] in Warsaw in accordance with the following guidelines:

- 40% subsidy for electric energy sources,
- 1% interest rate loan,
- maximum 15 years' financing period,
- subsidy cannot be applied for in case of obtaining finance from other public funds.

### **Projected cost and profitability of investment in photovoltaic panels on an agritourism farm**

The next part of the article presents economic effects of installing a system of photovoltaic modules on an agritourism farm hosting a four-member tourist group and using a 5 kWp photovoltaic system. Another assumption is that the whole amount of electrical energy produced is used on that agritourism farm (data provided by Fundacja BOŚ). The analysis results have taken into consideration an annual use of 5,000 kWh of energy on a farm and an average price of ca. 0.55 PLN/kWh. The total cost is PLN 2,750 (5,000 kWh x 0.55 PLN/kWh).

An optimally designed and maintained photovoltaic system with an installed capacity of 1 kW should produce 1,000 kWh of energy annually. Thus, a facility having a capacity of 5 kW should produce ca. 5,000 kWh (5 kW x 1,000 kWh). Actual production of electrical energy may oscillate between a lower and a higher level because of external factors such as atmospheric conditions or the weather. The above-presented calculations demonstrate that the assumed set of photovoltaic panels allows for meeting 90% of the demand for electricity on a farm hosting a four-member tourist group holidaying.

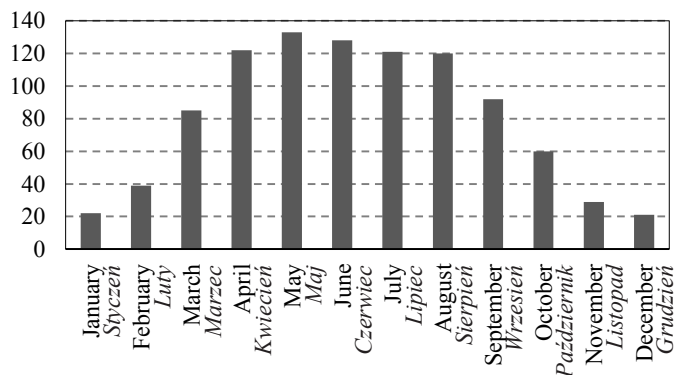


Figure 1. Electric energy obtained in particular months  
*Rysunek 1. Uzyskana energia elektryczna w poszczególnych miesiącach w skali roku*  
 Source/Źródło: [Lenarczyk 2013]

Table 2. Investment assumptions  
 Tabela 2. Rozkład założeń inwestycyjnych

| Assumption/Założenia                                                                                                                                | Unit/<br>Jedn. | Value/<br>Wartość |
|-----------------------------------------------------------------------------------------------------------------------------------------------------|----------------|-------------------|
| Installation capacity/Moc instalacji                                                                                                                | kWp            | 5                 |
| Gross unit cost (8% VAT)/Koszt jednostkowy brutto (8% VAT)                                                                                          |                | 6,200             |
| Gross total cost/Koszt całkowity brutto                                                                                                             |                | 31,000            |
| Gross installation cost after a subsidy (Prosument Programme subsidy 40%)/<br>Koszt instalacji po dotacji brutto (dotacja 40% z Programu Prosument) | PLN            | 18,600            |
| Credit amount/Kwota kredytu                                                                                                                         |                | 15,000            |
| Credit period/Okres spłaty kredytu                                                                                                                  | year/rok       | 5                 |
| Own input/Wkład własny                                                                                                                              | PLN            | 3,600             |
| Interest/Oprocentowanie kredytu:                                                                                                                    | %              | 1                 |
| Instalments proportion throughout credit period/Stosunek rat w skali kredytu                                                                        | -              | equal             |
| Principal and interest/Kwota kredytu z odsetkami                                                                                                    | PLN            | 15,384.15         |
| Interest/Odsetki                                                                                                                                    |                | 384.15            |
| Effective interest/Oprocentowanie rzeczywiste                                                                                                       | %              | 2.56              |
| Monthly instalment/Rata miesięczna                                                                                                                  |                | 256.41            |
| Cost with 2% inflation rate added/Koszt po uwzględnieniu 2,00% inflacji                                                                             | PLN            | 14,652.97         |
| Interest with 2% inflation rate added/Odsetki po uwzględnieniu 2,00% inflacji                                                                       |                | 347.03            |

Source: own calculations

Źródło: obliczenia własne

The charge for net-metered 500 kWh (5,000–4,500 kWh) may account for PLN 275 (500 kWh x 0.55 PLN/kWh) in a year's period. It is assumed that each good quality cell having a capacity of 1 kWp in perfect weather conditions may produce 1 kWh of electricity annually. A projected value of energy produced throughout a year indicating production efficiency in particular months is presented below. Figure 1 shows the amount of energy produced throughout a year.

Economic assumptions for the installation of a system of photovoltaic cells take into consideration theoretical values selected for the needs of a simulation. Detailed data are presented in table 2.

A sample investment in modernisation of 100 facilities (e.g. 80 agritourism farms and 20 public facilities) allows for obtaining 18 GJ of energy per year from one installation. In case of a system of 100 installations, up to 1,800 GJ may be saved annually.

## Conclusions

The authors' observations let them formulate the following generalisations and conclusions:

1. Renewable sources of energy constitute an alternative to traditional primary non-renewable energy carriers. Their resources replenish in the course of natural processes, which practically allows for treating them as inexhaustible. Moreover, obtaining energy from these sources, in comparison with traditional ones, is more environmentally friendly.
2. Planning renewable energy acquisition on an agritourism farm is based on identification of real energy needs that takes into consideration daily, seasonal and yearly fluctuations as well as possibilities of satisfying them by properly selected renewable resources.
3. The charge for net-metered 500 kWh (5,000 4,500 kWh) may account for PLN 275 (500 kWh x 0.55 PLN/kWh) in a year's period. It is assumed that each good quality cell having a capacity of 1 kWp in perfect weather conditions may produce 1 kWh of electricity annually.

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### Streszczenie

*Celem opracowania jest zaprezentowanie planowanych kosztów i opłacalność inwestycji fotowoltaicznych w gospodarstwie agroturystycznym. Szczególną uwagę zwrócono na efekt ekonomiczny zainstalowania systemu modułów fotowoltaicznych w gospodarstwie agroturystycznym, zamieszkałym przez czteroosobową grupę turystów wykorzystującą system fotowoltaiczny o mocy 5 kWp. Założono, że cała wyprodukowana energia elektryczna jest na bieżąco zużywana przez przykładowe gospodarstwo agroturystyczne. Wyniki analiz uwzględniały założenie charakteryzujące zużycie energii w gospodarstwie na poziomie około 5000 kWh w ciągu roku, gdzie cena energii wynosiła średnio 0,55 zł za 1 kWh energii elektrycznej. Kalkulując obliczenia za zużytą energię elektryczną w danym roku należało zapłacić 2750 zł (5000 kWh x 0,55 zł/kWh).*

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