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ANALYSIS OF PHOTOVOLTAIC SYSTEMS FOR FRENCH HOUSEHOLDS

ANALIZA PRZYDOMOWYCH SYSTEMÓW FOTOWOLTAICZNYCH WE FRANCJI

Abstract

The analysis, which has been conducted for four households in France, has shown that the use of photovoltaic panels for electric energy production has been economically effective. The analysis has been conducted using RETScreen® International software and compared with real data form system owners. The calculations were based on daily solar radiation and have been demonstrated using a simple payback period and internal rate of return. The majority of the photovoltaic system's necessary cost has been taken into account. The calculations have demonstrated that a simple payback time for systems set before 2012 is below 10 years, which is a half time of panels' life span. Moreover, the ecological effect on producing electric energy using analyzed systems has been calculated.

Keywords: photovoltaic, renewable energy source, solar energy

Streszczenie

Analiza przeprowadzona na czterech francuskich gospodarstwach domowych pokazuje, że stosowanie paneli fotowoltaicznych do produkcji energii elektrycznej jest ekonomicznie opłacalne. Analizę przeprowadzono w oparciu o program RETScreen® International, a wyniki porównano z rzeczywistymi wartościami przekazanymi przez właścicieli systemów fotowoltaicznych. Obliczenia oparte są na dobowym promieniowaniu słonecznym, a wyniki zobrazowane poprzez prosty okres zwrotu (SPBT) i wewnętrzną stopę zwrotu (IRR). Pod uwagę wzięto większość kosztów wzniesienia i utrzymania instalacji fotowoltaicznej. Wyniki obliczeń pokazują, że systemy zainstalowane przed 2012 rokiem charakteryzuje SPBT poniżej 10 lat, co jest połową okresu życia paneli. Ponadto wyznaczono efekt ekologiczny produkcji energii elektrycznej za pomocą systemów fotowoltaicznych.

Słowa kluczowe: fotowoltaika, odnawialne źródła energii, energia słoneczna

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1. Introduction

Photovoltaic systems (PV) may be the answer to the continuously rising energy prices. Installing them allows decreasing monthly households outcomes, due to selling energy produced by panels. Additionally, installing PV systems contributes into lessening CO_2 and other greenhouse gases emission, comparing with conventional power plants emission. In Poland, installing PV systems is mildly supported, as so they are rare. However, France strongly supports such projects.

2. Photovoltaic systems

The core element of photovoltaic system is the cell – it is made of silicon and semiconductors compound. Single cell provides power of 1–2 W. In order to gain greater power, it is necessary to combine them into modules and modules into panels or batteries [1–6].

Produced energy may be utilized by the recipient, accumulated or transmitted to the grid. Most often the law demands selling energy to the grid managing company.

The first step in calculating photovoltaic systems is to define its application (autonomic or connected to grid) and then select the panels of appropriate power. Unitary energy produced by 1 m^2 cell area during given time period equals:

$$E_j = N\eta_p [\text{kWh/m}^2] \tag{1}$$

where:

N – insulation [kWh/m^2] in given time period,

η_p – average efficiency of photovoltaic cell [%].

In order to calculate the amount of energy produced by all cells, their unitary energy have to be multiplied by the cells area.

PV cell efficiency depends highly on its temperature. As solar radiation increases the temperature of cell, its efficiency is dropping. New hybrid PV/T systems however, can be the answer to decreasing the temperature of panels [7].

3. Subject of analysis

The analysis has been set for four households located in the department of Isère, France. The systems had been installed between 2010 and 2012. Each system consisted of 16 panels installed on the roof and did not exceed 3 kW (owners of PV systems characterised by power output of over 3 kW are recognised as professional energy producers and as such are regulated by different laws). The analysis was conducted using RetScreem International software, which uses meteorological data provided by NASA [6].

The investments in photovoltaic are strongly encouraged in France. Companies that install PV systems hold agreements with banks, which grant them credits on preferential conditions. Those loans are paid off with money earned by selling electric energy produced

by PV system (it is assumed that the credit period will not exceed ten years, which is a half of the system's span life). Additionally, the government funds such investments with 4 K to 8 K € grants.

The object of analysis is to estimate the economical and ecological profitability of installing photovoltaic systems. The analysis is based on real electric energy production data. Calculations were conducted for the following systems.

Table 1

Analysed systems. Own study

No	Location	Year of installation	System's power [kW]	Inclination [deg]	Azimuth [deg]	Installation cost [€]	Energy price [€/kWh]
1	Miribel-les-Echelles	2011	2.80	45	45	19 000	0.584
2	Miribel-les-Echelles	2010	2.88	45	45	24 300	0.584
3	Miribel-les-Echelles	2012	2.80	45	30	19 000	0.388
4	St Aupre	2011	2.96	24	30	16 000	0.584

Fig. 1. Photographs of analysed systems, from left 1, 2, 3, 4 (own study)

As mentioned earlier, all systems' power is lower than 3 kW, table 1. Almost all systems' cost was lower than 20 K €. As one could see, systems set before 2012 are characterised by more favourable energy price, than the one set in 2012.

4. Results

Analysis has shown that in most cases, the annual production was greater than, or similar to the predicted one (Table 2). Moreover, for systems set before 2012, simple payback time is lower than 10 years, which is caused by much lower energy price in 2012. SPBT of the 2nd system is a bit higher, as the cost of installation was over 25% higher. Furthermore, annual life cycle savings for all instalations but the 3rd are around 1 K euro. Nevertheless, the three credited systems' debt service coverage is between 0.6–0.9.

Table 2

Analysis results. Own study

No.	Calculated annual production [MWh]	Real annual production [MWh]	SPBT [year]	IRR [%]	Annual life cycle savings [EUR]	Debt service coverage [–]	Annual GHG emission reduction [t_{CO2}]
1	3.004	3.686	6.3	–	1336	0.9	0.2
2	3.089	3.410	9.1	–	1054	0.72	0.2
3	3.004	2.765	17.0	5.5	23	0.58	0.2
4	3.314	3.226	6.3	16.2	1141	–	0.3

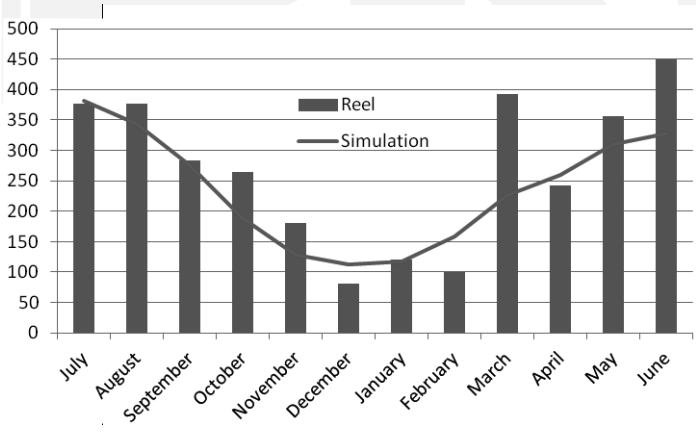

Fig. 2. Part of production history compared with the simulation provided by the installer of system Nº 4 (2011/2012) (owner's study)

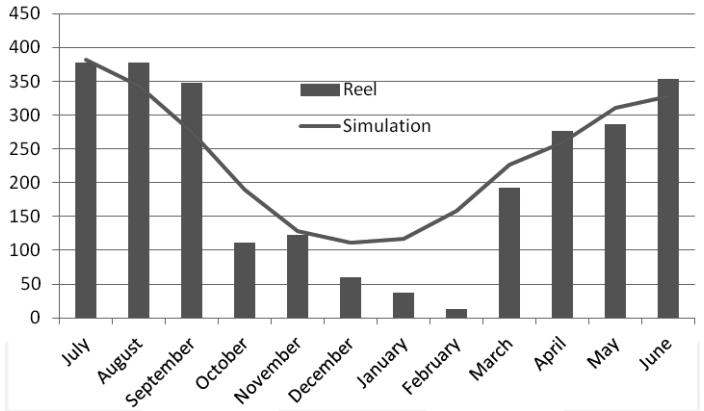

Fig. 3. Part of production history compared with the simulation provided by the installer of system N° 4 (2012/2013) (owner's study)

The installation of photovoltaic systems reduced the GHG emmision by about 0.2 tonnes of CO_2 annualy, whitch equals 85.9 saved liters of gas or 0.5 acres of forests.

Simulations prepared for system N° 4 were comapred with real production history.They show that most of the time the production is higher than predicted, but in two years' time did not show any trend.

5. Conclusions

In conclusion, the analysis has shown, that two years ago the investment in photovoltaic systems in France was more profitable than nowadays, which is caused by the Government lowering the energy price. Additionally, the simple payback time for most of the installations is relatively short and therefore the investment appears to be profitable.

Moreover, the analysis has shown that one household with photovoltaic installation reduces CO_2 emission only slightly. However, if we consider the number of such households in one village, the resulting emission reduction becomes more vivid.

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