

EXPERIENCE OF CONSTRUCTION AND OPERATION OF THE FIRST SOLAR POWER PLANT IN BELARUS

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Abstract

In 2014 in Bobruisk the first in the Republic of Belarus solar power plant (SPP) was put into operation with a total capacity of 2.06 MW. One installed kW from this solar plant provides about 1000 kWh of electricity during a year. The cost of energy produced by SPP can range from 0.06 to 0.09 USD / kWh depending on the particular economic circumstances in the country. The results of the first SPP start-up could be used to determine the technical potential of photovoltaics in Belarus: about 330 bill kWh of electricity per year.

Key words: solar, power plant, potential, cost of energy

Currently photovoltaics is the most rapidly developing area in the energy sector. According to the International Energy Agency the capacity of solar power plants (SPP) increased from 70 to 138 GW during 2010-2013, i.e. by almost 2 times, and even up to 185 GW in 2014, i.e. - 34% in comparison with 2013 year. SPP production efficiency reached 20%, and its cost, for example, in the United States fell from 32 US cents in 2009 to 7.2 cents in 2014 (Berezkin 2015). In that same year in Germany for the first time the production of electricity at SPP exceeded production of electricity from natural gas by about 7%.

In Belarus the theoretical potential of solar energy is the biggest of all the renewable energy sources (RES) (Mikhalevich 2014). However, until recently the energy of the solar radiation has been used to a lesser extent than other sources of renewable energy. It used to be mainly due to the higher capital cost of solar power plants in comparison with the traditional ones and the absence of own SPP elements production on an industrial scale. The situation began to change with the introduction of raising factors in RES electricity sales to the grid in accordance with the law of the Republic of Belarus "On Renewable Energy Sources" adopted in December 2010. Initially, the multiplying factor for solar power was set at 3.0 for the first 10 years of power plant operation (and 0.85 after 10 years), then it was reduced in to 2.7 in 2014. Unlike in the developed countries the payment of high tariffs in Belarus would not be at the expense of state subsidies but of the energy producer, i.e. paid by the consumer.

In some EU countries (Czech Republic, Germany, etc.) government incentives for renewable energy are being gradually reduced and a transition to renewable energy operation in market conditions with traditional sources of energy is beginning as well. In 2015 Decree of the President of the Republic of Belarus granted the Government with the right to set quotas for the construction of power plants based on renewable energy. Therefore, the fixed value of raising factors is the maximum possible and actual values for each case are determined during tendering for a quota.

In February, 2014 in Bobruisk 1st unit of the first in the Republic of Belarus solar power plant (SPP) was put into operation, in May - the second one, and in August 2014 - all 3 units of SPP with a total capacity of 2.06 MW. SPP supplies Mogilevenergo system with the produced energy.

The station consists of 8240 solar panels (modules) of Chinese production (company Lux Power) with size of 1,6x1,0x0,04 m, power 245-250 W each (Fig. 1) and efficiency of 17.7% with the Chinese and partially French inverters (Fig. 2) for converting direct current into alternating. The modules are mounted at an angle of 37% to the horizon and focused on the position of the Sun in 1 a.m. (solar noon). Specific investment cost for the construction of the station is 1500 USD / kW, which is comparable to wind power plants, approximately twice higher than for the combined-cycle power plants and twice lower than for nuclear and hydro. Construction time is about 3 months.



Fig 1. Bobruisk SPP panels



Fig 2. Bobruisk SPP inverters

Performed pre-calculations show that one installed kW from this solar plant provides about 1000 kWh of electricity during a year in Belarus.

After Bobruisk SPP commissioning the cost of electricity production was calculated without taking into account:

- cost of credit;
- finance discount;
- the costs of decommissioning after its lifetime;
- the degree of panels degradation,

according to the formula

$$C = \frac{C_{cap} + C_{fuel} + C_{oper}}{Q_{res}},$$

where C_{cap} , C_{fuel} , C_{oper} – capital, fuel and operational cost components;

Q_{res} – amount of electricity, produced by the source during lifetime.

Considering SPP operation term for 30 years, taking into account taxes and minor repairs as well, production cost is to be 5.33 cents / kWh.

More accurate calculations conducted by differential methods, taking into account the above mentioned 4 conditions, show that the cost of energy produced by SPP, can range from 6 to 9 cent / kWh depending on the particular economic circumstances in the country, that is: discount rate on loans, money discount degree, tax component, etc.

Thus, the positive aspect of the solar plants construction in the Republic of Belarus is a relatively reasonable cost of energy produced. The energy is given to the network in the daytime – during large power system loads.

A significant drawback of solar power is its seasonal nature (Fig. 3). Maximum performance is achieved from May to August, when the average peak load duration of the month ranges from 133 to 159 hours for different areas of Belarus, the average of the year is 1006 hours for the Vitebsk region and 1082 – Gomel one.

For Bobruisk SPP the peak load factor was 0.15 in May 2015 and 0,009 – in December 2014. For comparison, in 2011 the load factor of steam turbine power plant of the Belarusian energy system amounted to 0.43, hydroelectric and wind turbines – 0.2 and mini-CHP plants - 0.57. Design load factor for the Belarusian Nuclear PP – 0.92.

Another characteristic of the solar power is its uneven generation both daily during the month and hourly during the day (Fig. 5-7).

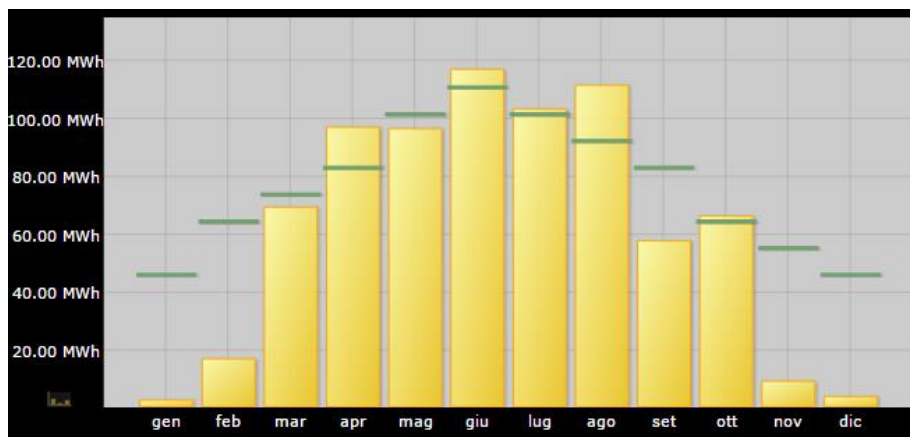


Fig 3. Generation distribution at the 2nd unit of Bobruisk SPP during 2015 (in months)

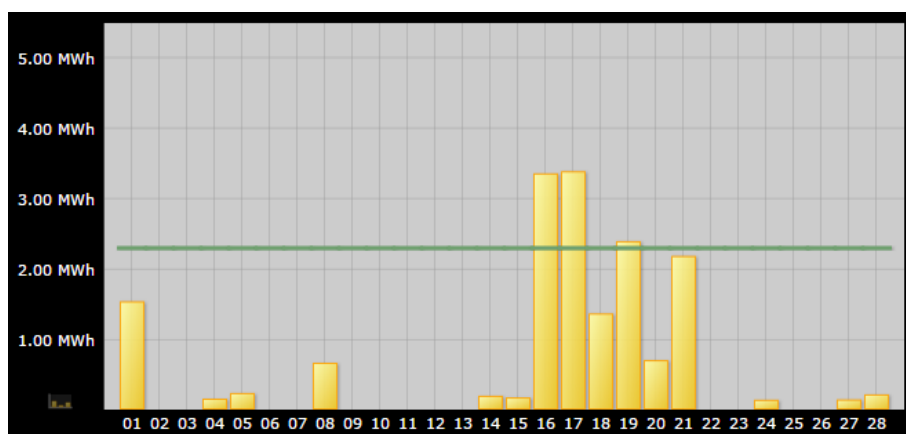


Fig 4. Generation distribution at the 2nd unit of Bobruisk SPP (February 2015, daily)

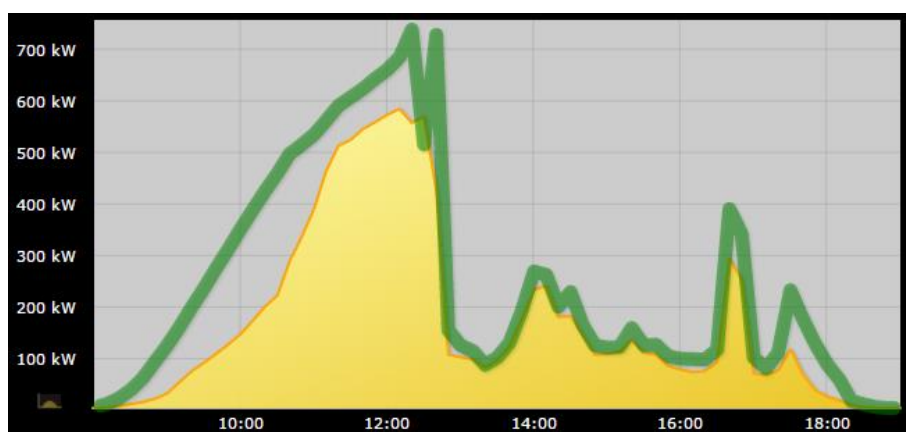


Fig 5. Generation distribution at the 2nd unit of Bobruisk SPP (February 27, 2015, hourly)

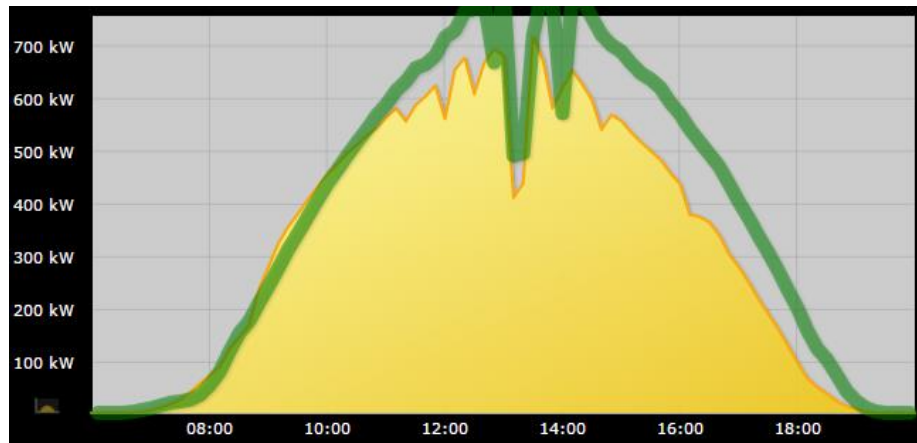


Fig 6. Generation distribution at the 2nd unit of Bobruisk SPP (September 14, 2015, hourly)

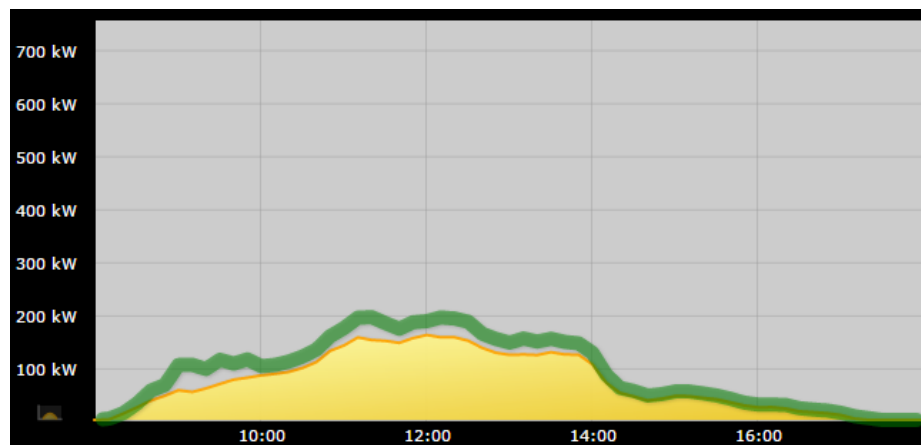


Fig 7. Generation distribution at the 2nd unit of Bobruisk SPP (November 6, 2015, hourly)

Therefore, commercially solar power may compete with other energy producers till there is a preferential sale of electricity to the grid at an increased rate. In such circumstances, the implementation of the SPP is limited, because this situation inevitably leads to an increase in tariffs for consumers.

The results of the first solar power start-up can be used to determine the technical potential of photovoltaics in Belarus. The land area occupied by the Bobruisk SPP is a little more than 4 hectares and produces about 2 mill kWh per year. According to the state land register (01.01.2004) total land area of the Republic of Belarus is 20 759.0 thousand hectares, including:

- agricultural land - 9106.7 (43.9%),
- arable land - 5568.7 (26.8%),
- forest land and land covered with trees and bushes - 8750.2 (42.1%),
- drained swamps - 923.5 (4.4%),
- under water - 477.4 (2.3%),
- under buildings and roads - 843.1 (4.1%),
- and other unused land - 658.1 (3.2%).

The unused land given to solar energy production could provide 330 billion kWh of electricity per year.

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