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Simulation of an autonomous power supply system based on lithium-iron-phosphate ($LiFePO_4$)

Mikhail Popov[1], and *Oleg* Maniv[1,*]

[1]National Research Tomsk Polytechnic University, 634050 Tomsk, Russia

Abstract. Optimization of equipment composition and operation mode of power supply systems with renewable energy sources is an important and urgent task. As a result of the study, graphs of generation and consumption of electrical energy, charge-discharge characteristics of electric energy storage devices were constructed, the type and capacity of storage batteries were selected, the solar power plant scheme was developed and the main equipment was selected in accordance with the scheme, the economic efficiency of the solar power plant project was estimated and the payback period was determined.

1 Introduction

The most serious technical problem of the PV power plant (PVP) operation is a strong dependence of power generation on the plant's geographical location and climate conditions. Therefore, a reliable prediction of the electrical power generation is crucial for the PVP design to enable the appropriate choice of the plant equipment that ensures the energy and economic efficiency of the PVP.

Increase the capacity utilization factor of solar cells in autonomous power supply systems is possible through the use of energy storage devices, first of all it is batteries.

Different types of batteries are not only of different cost, but differ in the main parameters: the number of recharge cycles, the maximum shelf life, the yield capacity, internal resistance, size, volume of the electrolyte, the temperature range of work, the possibilities of accelerated charging. The discharge characteristics of the batteries depend on the discharge current. Battery life also depends on operational characteristics, frequency and depth of charge-discharge, charge and discharge current.

Different types of batteries have not only a different price, but differ in basic parameters: the number of charge cycles, the maximum period of storage, give capacity, internal resistance, the size, the electrolyte, operating temperature range, fast charging capabilities. The discharge characteristics of the batteries depend on the discharge current. Battery life also depends on operational characteristics, frequency and depth of charge-discharge, charge and discharge current.

* Corresponding author: mix_mix13@tpu.ru

When designing an autonomous power supply system based on renewable energy sources, we will consider lithium-iron-phosphate batteries. This is the most perfect, to date, type of battery. In addition, these types of batteries are low-maintenance, hence the operating costs associated with their use will be significantly lower. In this regard, the use of $LiFePO_4$ batteries is most convenient and profitable for a solar power plant. The main parameters that are usually used when choosing electric batteries are capacity, service life and cost.

The research aims to develop an improved method to predict the plant power output under actual operating conditions.

2 The object of the study and the method requirements

The object of the study is a stand-alone PVP, its typical scheme is shown in Fig. 1.

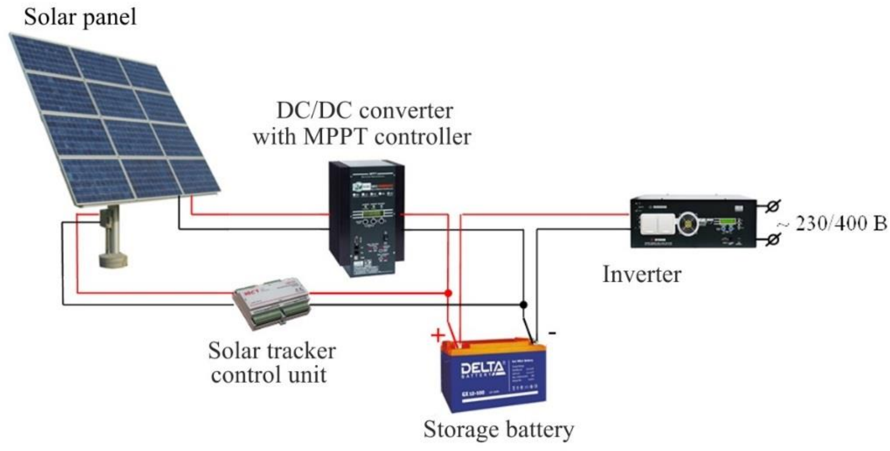

Fig. 1. Scheme of the PV power plant.

Solar energy comes from batteries on the battery and accumulates there a charge. Recharged completely, the battery begins to function as an uninterrupted power source during the night hours and hours of shortage of solar insolation. In hours of excessive insolation, the batteries act as energy storage devices, the system works directly on solar panels, consuming power for the work of power receiving devices [1-5].

For the power supply object considered in this work for power receivers in the city of Sochi in the Krasnodar Territory, the values of solar radiation are shown in Table 1.

Table 1. Solar radiation in Sochi.

Solar radiation Summ, kW·h/m²											
Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Okt	Nov	Dec
138.7	172.1	198.3	209.7	233.7	236.9	255.6	246.6	223.6	188.7	139.8	104.13

The average value of solar radiation for the year is 195.68 kW·h / m², the total generation of electricity for the year: 71421.87 kW·h, which is one of the best indicators in Russia. [6]

Within the studies performed is selected accessory to reserve the object with maximum power connected power devices - 102 kW [7, 8]. Below is a real daily load graph of the object under study (Fig. 2).

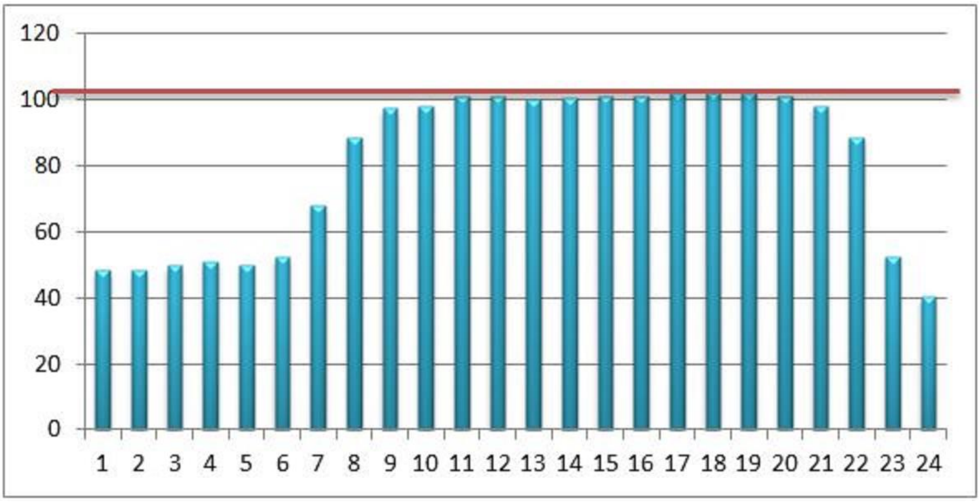

Fig. 2. Daily load graph.

2 Mathematical simulation of the PVP operating modes

The primary solar energy value available for conversion depends on the total solar radiation intensity at the installation site, geographical location of the plant, the solar panel spatial orientation, and the external meteorological factors: cloudiness level and surface reflection coefficient.

For effective use of batteries, it is necessary to accurately select the required capacity, taking into account the modes of operation of the consumer, the source and characteristics of the batteries. To do this, we will perform a mathematical simulation of the PVP operation. The simulation results are shown in the graphs below. On the figure 3 represents simulation results with insufficient battery capacity in the sistem. Figure 4 represents it closely.

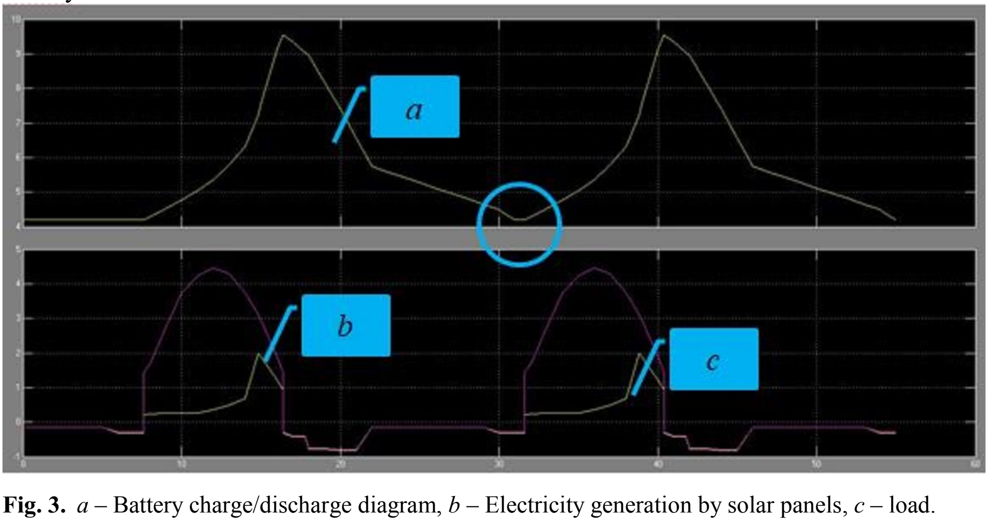

Fig. 3. *a* – Battery charge/discharge diagram, *b* – Electricity generation by solar panels, *c* – load.

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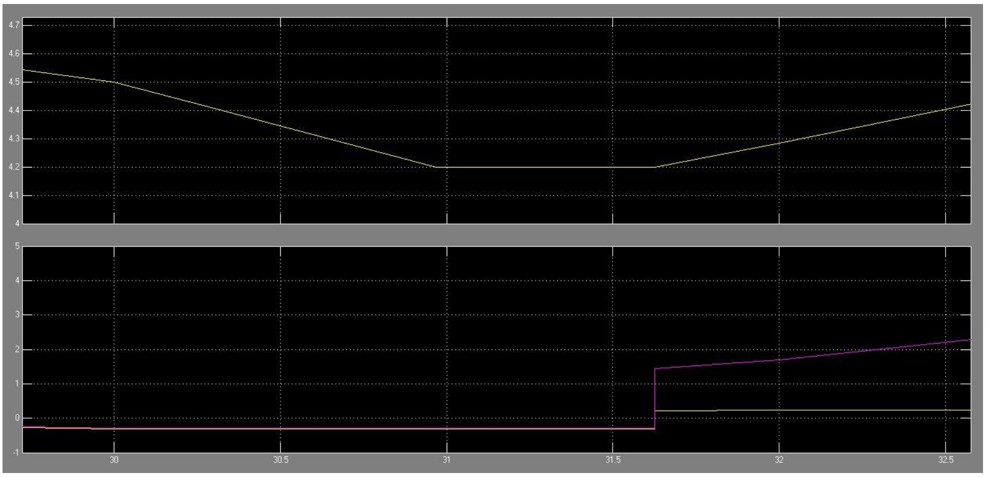

Fig. 4. Battery discharge depth.

When the battery capacity have coosen whrite, there is no unused battery capacity and there is no insufficient battery capacity, it is shown on the figure 5.

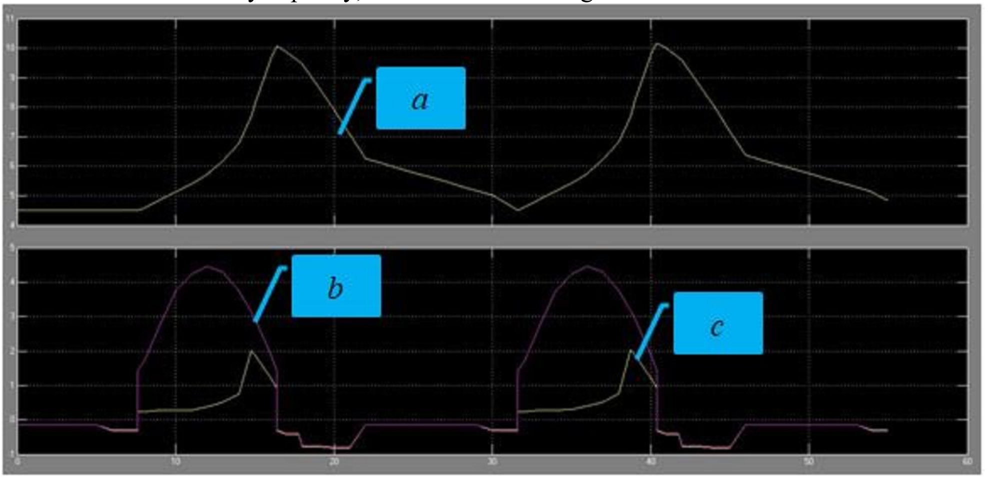

Fig. 5. *a* – Battery charge/discharge diagram, *b* – Electricity generation by solar panels, *c* – load.

3 Conclusion

An autonomous power supply system based on SES and battery was created. Two processes of the system were simulated for a given load schedule at different times, during the winter and summer solstice on the basis of simulation results, it was established that the system is fully operational and autonomous. An additional power supply is not required.

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