

CONDITIONS FOR THE EFFECTIVE USE OF STAND-ALONE POWER SOURCES

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Currently, according to world trends, the transition from centralized electricity to decentralized in various sectors of the economy. Therefore, in order to provide such households with electric energy, it is expedient to create their own electricity supply systems from stand-alone power sources, which include both backup power plants (BPP) and renewable energy sources (RES).

Reliable and efficient power supply of these farms is primarily based on the identification of the relationship between energy production and its consumption. But when it comes to electricity supply from autonomous energy sources, it is quite difficult to detect such interconnection at once, due to the stochastic nature of the energy flow and the energy load of the consumer.

Thus, the purpose of the work is to solve the problem of forecasting and harmonizing the processes of electricity consumption and electricity in such a way that the control of the electricity supply process was automatic, while the energy needs of the consumer were maximally secured by the BPP and minimal use of RES.

For an example, consider the following structure of the automated power supply system (APSS) from stand-alone power sources, Fig. 1.

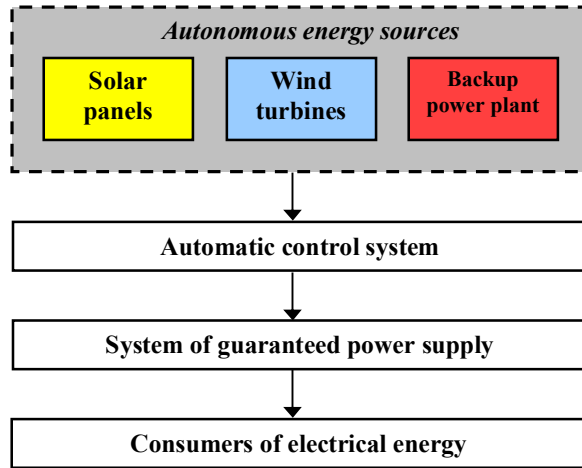


Figure 1 - The structure of the automated energy supply system from stand-alone power sources

The APSS automatic control system must provide efficient electricity from solar panels (SB), wind turbines (WT) and RES. The system of the guaranteed power supply includes a stand-alone inverter and rechargeable batteries (RB). Efficient power supply from these energy sources must be performed in such a way that the following conditions are met:

$$\begin{cases} P_1 \cdot n_1 + P_2 \cdot n_2 + P_3 \cdot n_3 + P_4 \cdot n_4 = P_{\max} \\ n_1 \cdot C_1 + n_2 \cdot C_2 + n_3 \cdot C_3 + n_4 \cdot C_4 \rightarrow \min \\ P_3 \cdot n_3 \cdot t_{\text{aux}} \rightarrow \min \\ t_{\text{use}} \cdot Q_n \cdot C_n \rightarrow \min \end{cases}, \quad (1)$$

where P_{max} - maximum load of the consumer; n_1, n_2, n_3, n_4 - respectively, the number of SB, WT, RES, RB; P_1, P_2, P_3, P_4 - respectively, the power of the SB, WT, RES, RB; C_1, C_2, C_3, C_4 - respectively, the cost of the SB, WT, RES, RB; t_{use} - time using of RES to meet energy needs; Q_n, C_n is, respectively, the expense and cost of fuel that needs to be spent on RES to meet the energy needs of the consumer.

The fulfillment of the conditions in (1) will allow the maximum use of solar and wind energy and minimize the use of RES, which will reduce the cost of fuel associated with its work.

In addition to efficient electricity supply, the indicator is as important as the total cost of power plants. It is necessary to ensure the minimum cost of all power plants that are part of the APSS, in such a way as to maximize the energy needs of the consumer. The criterion of minimum costs of the total cost of power plants is proposed, taking into account their operational characteristics in a certain area:

$$E_{\Sigma} = E_1 + E_2 + E_3 + E_4 \rightarrow \min, \quad (2)$$

where E_1, E_2, E_3, E_4 - respectively, the specific cost of 1 kWh electrical energy for a day from the SB, WT, RES and RB.

For the rational and efficient use of autonomous energy sources, it is necessary to determine the priorities for the sequential switching of power plants.

In [1, p. 70] the algorithm of operation of the unit of control of the autonomous power installation is proposed, which consists in using the criterion of the maximum aggregate efficiency of the power plant. For this purpose, the principle of priority use of energy sources was developed and used. Power supply to the consumer is carried out directly from the primary source (with maximum efficiency). With excess power of the primary source, electricity is accumulated in electrochemical accumulators.

However, this criterion does not take into account the following performance indicators of power plants: lifetime, readiness of the installation for switching on, specific value of 1 kWh energy, etc. Thus, this criterion does not take into account all operational conditions of the system.

For efficient use of power plants in work [2, p. 253] the following criterion was proposed:

$$J = \frac{E_1 \cdot W_1 + E_2 \cdot W_2 + E_n \cdot W_n}{N_\Sigma} \rightarrow \min, \quad (3)$$

where N_Σ - total amount of energy produced by power plants for a certain period of time; E_1, E_2, \dots, E_n - respectively, the specific cost of 1 kWh electric energy; W_1, W_2, \dots, W_n - amount of energy produced by the power plant for a certain period of time.

However, this criterion also does not fully take into account all operational conditions of the system (work life, duration of technical breaks, etc.).

To achieve this goal it is necessary that the criterion of the sequence of switching on power plants should take into account operational conditions of the system and performance indicators of each power plant:

- unit cost 1 kWh energy produced by the i -th power plant E_i ;
- quantity of energy produced by the i -th energy power plant for a certain period of time W_i ;
- resource of the i -th power plant r_i ;
- readiness of the i -th power plant to switch on L_i ;
- duration of technical breaks in the operation of the i -th power plant B_i .

In addition, each indicator included in the criterion must be given a corresponding weighting factor. Then the criterion for determining the priorities of the sequence of switching on power plants will be as follows:

$$J = E_i \cdot a + \frac{b}{W_i} + \frac{c}{r_i} + L_i \cdot d + B_i \cdot e \rightarrow \min, \quad (4)$$

where a, b, c, d, e is the weighted coefficient of the indicator in the criterion.

For example, for a power unit with an REA, the specific cost can be determined using the following expression [2, p. 253]:

$$E_i = \frac{S_i}{W_i \cdot T_i}, \quad (5)$$

where S_i - cost of power plant; T_i - number of hours of operation of the power plant in a certain period.

Similarly, the specific cost of a power plant can be determined, while the cost of fuel must also be taken into account.

Resource of the power plant, as a rule, is given in the passport of technical characteristics provided by the manufacturer of this power plant. The willingness of the power plant to switch on is determined by the principle of operation of this power plant, for example, the presence of engines requires a certain amount of time to start the power plant and generate electricity. Duration of technical breaks is the time at which a power plant will not be able to generate electricity due to any technical failures that result in the inability to operate the power plant.

After preliminary studies it was determined that for determining the parameters of weight factors in the criterion of the sequence of switching on power plants, expression (4), it is expedient to use the methods for determining expert assessments. The most expedient is to use the method of pair comparisons and to evaluate the importance of parameters in balls.

Conclusions. The terms of effective use of autonomous energy sources proposed in the work can be used for various combinations of RES and any consumers. The use of the proposed criterion makes it possible to determine the conditions for efficient use of autonomous energy sources and the sequence of switching on power plants, while taking into account the operating conditions of APSS autonomous consumers. The criterion of the priority of the sequence of switching on power plants in the APSS allows the efficient use of energy from RES in accordance with the energy needs of the autonomous consumer.

Literature:

1. Попель О. С. Автономные энергоустановки на возобновляемых источниках энергии / О. С. Попель // Энергосбережение. – 2006. – № 3. – С. 70-76.
2. Голик О. П. Моделі прийняття рішень для систем автоматизації процесу керування енергопостачанням автономних споживачів в умовах невизначеності вхідної інформації / О. П. Голик, Т. В. Міняйчева // Інтелектуальні системи прийняття рішень та проблеми обчислювального інтелекту: Матеріали міжнародної наукової конференції. –Херсон: ХНТУ, 2012. – С. 252-254.