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FEATURES OF CALCULATION THE LOAD FOR OFF-GRID SOLAR POWER PLANT.

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Stand-alone (off-grid) solar power plant (SPS) are used to supply electricity to individual houses, farms where centralized power supply network is not available. Their main advantage is independence from power supply networks.

The calculation of the load for off-grid SPS can be performed:

- according to the total rated power of PV array, using the rated power and the current operating time of the consumer per day; basing upon the calculations, the daily active power load curve is constructed;

- according to the estimated power (maximum for 30 min), using the nominal power of the consumer and the demand coefficient k_d; power demand is calculated according to a typical load profile.

It should be noted that the estimated power of the PV array is usually 20-45% less than its total nominal power and practically corresponds to the actual power demand.

First, a list of station consumers is drawn up (for example, in the form of Table 1) with a suggestion of their nominal power P_{nom}, the type of voltage (constant, variable) and its value U_{nom}.

Table 1

An example of a consumer list of a country house off-grid SPS

N.	Name of consumer	Nominal voltage, U_{nom}, V	Nominal power, P_{nom}, W	Number, n
1	Electric kettle	~ 220	800	1
2	Microwave oven	~ 220	1000	1
3	Refrigerator	~ 220	350	1
4	TV	~ 220	100	2
5	Iron	~ 220,	700	1
6	PC	~ 220	300	1
7	Vacuum cleaner	~ 220	600	1
8	Air conditioner	~ 220	1000	1
9	Lighting -rooms; -kitchen, bathroom, etc.	= 48	 50 30	 1 1
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To construct standard daily active power profiles for off-grid SPS consumers, data based on long-term experimental studies of country and residential buildings are used. These findings take into account the deterministic, averaged load methods for the accepted time interval.

Estimated (maximum) power of SPS:

$$P_{max} = k_d \sum_{i=1}^{n} P_{m.b.i}, \qquad (1)$$

where n, k_d are the number of similar consumers and the demand factor, respectively.

$P_{m.b.i}$ is the power of the i-th consumer reduced to the main load power bus, which is calculated with taking into account the efficiency of the i-th consumer $\eta_{c.i}$ and the inverter η_{inv}: $P_{m.b.i} = \dfrac{P_{n.i}}{\eta_{c.i} \cdot \eta_{inv}}$,

where $P_{n.i}$ is the nominal power of the i-th consumer.

When such data is not available, the efficiency of a consumer with a power of more than 1000 W can be taken in the range 0.8–0.9, with a power less than 1000 W – in the range 0.7–0.8. The efficiency of the inverter can be approximately taken equal to 0.9 [1, 2].

According [3] the demand coefficient for houses of aggregate power are given in table 2.

Table 2

Demand coefficients for apartment buildings

Power, kW	Up to 14	20	30	40	50	60	70 and more
Demand coefficient	0,8	0,65	0,6	0,55	0,5	0,48	0,45

The method for determining the estimated load of the node with a small number of consumers according to the demand factor is inappropriate since it leads to a significant increase in the estimated power of the station. The need to use the demand factor with a small number and capacity of consumers proceeds from the fire safety requirements and is based on the possibility of simultaneous operation of all consumers. For such projects, it is most advisable to use a "smart house" as it requires much less power of electrical equipment and protective equipment on the station.

Using the typical daily load profiles represented in Figure 1, the following data are calculated:

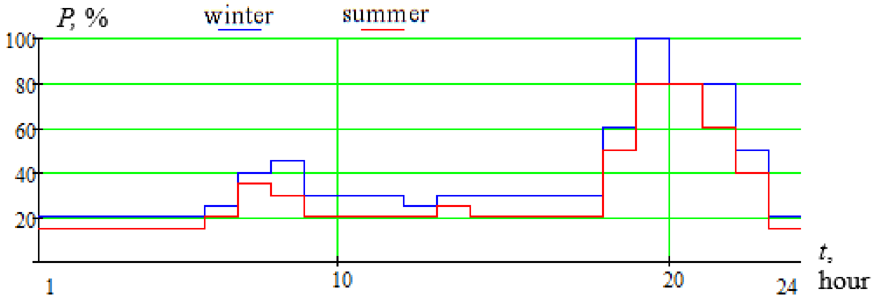

Figure 1 – Typical daily active power profile of residential consumers at home for winter and summer

- the corresponding step of the typical profile of active loads (P_i, kW) at the known design (maximum) load of the node (P_{max});
- consumption of active electricity at a certain time of the day (kWh) for the winter and summer periods:

$$P_i = \frac{n\% \cdot P_{max}}{100\%}, \qquad (2)$$

where P_i is the load power at a certain time of the day, kW;

n is ordinate of the corresponding step of the typical profile, %;

$P_{\max}$ is calculated maximum load, kW.

The calculation of the daily consumption of active energy is made according to the following formula:

$$W_{\text{cons}} = \sum_{i=1}^{24} P_i \cdot t_i\,, \qquad (3)$$

where t_i is the time of day.

A SPS can supply electrical appliances of house, workshop, farm provided that the energy consumption (W_{cons}) does not exceed the amount of electricity generated by the station (W_{gen}).

The use of a daily power profile for household and agricultural consumers, complexes for the industrial production of agricultural products makes more accurately determine the consumption of electricity per day, depending on the season of the year, which leads to a decrease in the calculated capacity of off-grid SPS.

An even distribution of the load during the day will further reduce the off-grid SPS power, which leads to a decrease in capital costs.

References

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