CALCULATION OF THE SOLAR ENERGY SYSTEM

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Abstract. This article presents the analysis and calculation of the solar energy system. The authors used practical research and calculations based on the geographical location and cyclical time periods of the sun's position. The calculation was made on the example of a conditional residence with minimal electrical equipment and average energy consumption, taking into account the use of electrical appliances with energy-saving technologies.

Keywords: solar panel, energy saving, alternative energy, battery, inverter, hydrocarbon fuel.

Introduction. Getting energy from the processing of hydrocarbon fuels causes serious damage to the nature and health of all living things that populate our planet, the Earth. And hydrocarbon fuel is not unlimited. Such a disappointing forecast makes countries engaged in the production of hydrocarbon fuels think about switching their activities to more environmentally friendly, technological industries that do not require hydrocarbon fuel. And it's time to think about switching to more environmentally friendly types of energy. [1]

Solar heat, which we have in excess (300 days a year), and the appropriate use is not only a benefit in monetary terms, it is also useful for humanity, which is slowly but surely destroying nature with harmful emissions to the atmosphere. So how to use this priceless gift to advantage. [2]

One of the most promising types of obtaining eco-friendly energy is solar panels and installing them on residential premises is beneficial not only for residents but also for the state that will save on hydrocarbon fuel (the main air pollutant) that is burned for energy production at thermal power plants. The main task is to determine the number of solar panels (how much energy a single solar panel can provide).

Methods and materials.

Types of solar modules-panels. Heliopoli modules assembled from solar cells, otherwise the photovoltaic converters. Two types of FEP have been widely used.

Fig-1. Polycrystalline element

Fig-2. Single-crystal element

They differ in the varieties of silicon semiconductor used for their manufacture, this is:

• Polycrystalline (Fig-1). These are solar cells made from silicon melt by long-term cooling. A simple production method determines the availability of prices, but the performance of the polycrystalline version does not exceed 12%.

• Monocrystalline (Fig-2). These are elements obtained by cutting into thin plates of artificially grown silicon crystal. The most productive and expensive option. The average efficiency is around 17 %, and you can find single-crystal solar cells with higher performance. Polycrystalline solar cells of a flat square shape with a non-uniform surface. Monocrystalline varieties look like thin uniform surface structure squares with cut corners (pseudo-squares).

Structural diagram of operation of solar power supply (Fig-3) [4]**.** Visually, the General scheme of the electrical circuit and its principle of operation look very simple. Solar modules are the first component of a power plant. These are thin rectangular panels assembled from a certain number of standard plates-solar cells. Manufacturers make photopanels different in electrical power and voltage, a multiple of 12 volts.

Flat-shaped devices are conveniently located on surfaces that are open to direct rays. Modular blocks are combined by means of mutual connections in a heliobattery. The task of the battery is to convert the received energy of the sun, giving out a constant current of a given value.

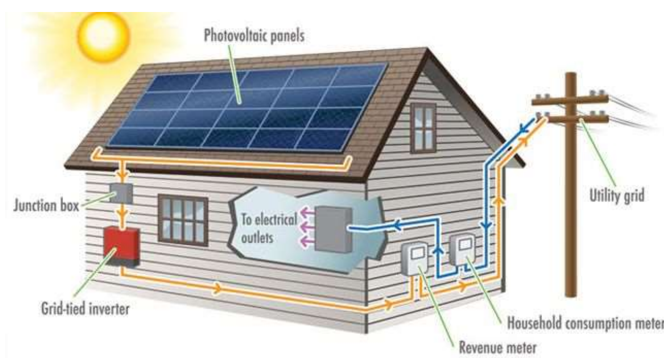
Electric charge storage devices – batteries for solar panels whose role is, when consumed from a centralized network, energy accumulators are stored with electricity.

They also accumulate its excess if the current of the solar module is sufficient to provide the power consumed by electrical appliances.

The battery pack gives the circuit the required amount of energy and maintains a stable voltage as soon as the consumption in it increases to an increased value. The same happens, for example, at night when the photo panels are not working or during low-sun weather.

The controller is an electronic intermediary between the solar module and the batteries. Its role is to regulate the battery charge level. The device does not allow them to boil from overcharging or drop the electric potential below a certain norm necessary for the stable operation of the entire solar system.

It converts the direct current of the solar module and batteries into alternating current with a potential difference of 220 volts. This is the working voltage for the vast majority of household electrical devices.



Structural diagram of the energy system (Fig-3)

Calculation of the power of solar panels. To calculate the power of solar panels, you need to know the energy consumption for a certain time (for a convenient calculation, take a monthly period). For example, if the energy consumption is 150 kW*h per month, it is necessary that the solar panels produce an equal amount of energy. Solar panels generate solar energy only during daylight hours. And they give out their rated power only when there is a clear sky and the sun's rays fall at a right angle. When the sun falls at angles, the power and electricity generation noticeably decrease, and the sharper the angle of incidence of the sun's rays, the greater the power drop.

It is also necessary to take into account the drop in the power of solar panels in cloudy weather (15-20 times), even with light clouds and haze, the power of solar panels falls by 2-3

ISSN: 2394-3696, Website: www.ijiert.org, Organized on 24-25 April, 2020

times. When calculating it is better to take the working time at which the solar panels work almost at full capacity, equal to 9 hours, this is from 8 am to 5 PM. Panels, of course, will work from dawn to dusk in the summer, but in the morning and evening the output will be quite small, only 20-30% of the total daily output, and 70% of the energy will be generated in the interval from 8 to 17 hours.

Thus, an array of panels with a capacity of 1 kW (1000 W) for a summer Sunny day will give out 9 kW*h of electricity for the period from 8 to 17 hours, and 270kw*h per month. Plus, another 5kW (30%) for the morning and evening, but let it be a reserve as possible partly cloudy. And the panels are installed permanently, and the angle of incidence of sunlight changes, so naturally the panels will not give out their power at 100%. If the array of panels is 2 kW, then the energy output will be 540 kW*h per month. And if there is one panel per 100 watts, then it will give only 900 watts*h of energy per day, and 27 kW per month.

Calculation of battery capacity for solar panels. The minimum reserve of battery capacity, at night. For example, if 3 kW*h of energy is consumed at night, then the batteries must have such a reserve of energy. If the battery is 12 volts 150 Ah, then the energy in it will fit 12 * 150=1800 watts (1.8 kW). But the batteries can't be 100% discharged.

Specialized batteries can be discharged up to a maximum of 70%, if more, they quickly degrade. If you install conventional car batteries, they can be discharged by a maximum of 50%. Therefore, you need to put twice as many batteries as required, otherwise they will have to be changed every year or even earlier.

The optimal battery capacity reserve is the daily energy reserve in the batteries. For example, if the daily consumption is 15 kW*h, the working capacity of the battery should be exactly the same. Then you can easily experience 1-2 cloudy days without interruptions. At the same time, on normal days during the day, the batteries will be discharged by only 20-30%, and this will prolong their operation time.

The inverter (12/24/48 V 220V energy Converter) has an efficiency of 70-80%.

Taking into account the loss of energy received from solar panels in batteries, and on the conversion of DC voltage to AC 220V, the total loss will be about 40%. This means that the storage capacity of batteries should be increased by 40%, and also increase the array of solar cells by 40% to compensate for these losses.

As a result, the calculation of the number of solar panels looks like this:

- accept that solar panels work only 9 hours in summer with almost maximum power
- to calculate their consumption of electricity per day
- Divide by 9 and you get the desired power of the array of solar cells
- add 40% to battery and inverter losses

The consumption of residential premises is 150 kW*h per month, divided by 30 days = 9 kW, divided by 10 kW for 9 hours, you get 1.1 kW. Add to this figure 40% losses on the battery and in the inverter, 1.1+0.44=1540watt. As a result, to power a private home in the summer, you need an array of 1.6 kW. But in order to get enough energy even in spring and autumn, it is better to increase the array by 50%, that is, plus 1 kW. [3]

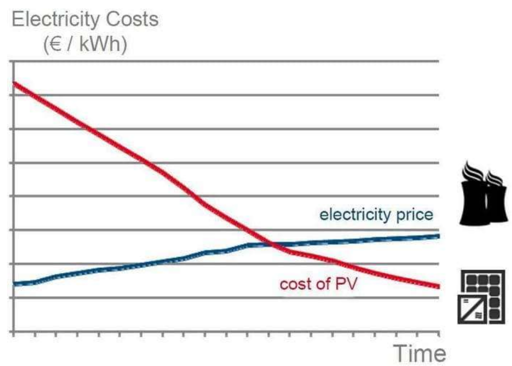
Conclusion. With the development of technologies related to solar energy, the cost of components is reduced. This is the fact that the cost of solar panels is constantly getting cheaper. The cost reduction is approximately 8-10% per year.

And the fact that electronics are developing electronic components and devices of solar energy systems are becoming more reliable and efficient every year. Therefore, the number of component replacements (controllers and inverters) can be 1 time — in 10 years, which will work for the entire life of solar panels.

ISSN: 2394-3696, Website: www.ijiert.org, Organized on 24-25 April, 2020

Not an unimportant element that makes up the solar energy system batteries are also being improved maybe in the near future there will be a technology on the market that will allow cheap and reliable accumulation of electricity.

And these revolutionary changes allow you to reduce the cost of solar energy systems and allow you to pay back in the shortest possible time than traditional thermal power plants, which is shown below in the graph of the payback of the solar energy system (Fig. 4). [5]



Energy system payback chart (Fig-4)

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