Prospects for the solar energy development in housing construction: an assessment of economic efficiency

A N Sekisov1*, S V Ovchinnikova1, M S Norenko2, V S Matevosyan2

1Kuban State Agrarian University I.T. Trubilin, 13, Kalinina, Krasnodar, 350044, Russia
2Kuban State Technological University, 2, st. Moscow, Krasnodar, 350072, Russia

E-mail: alnikkss@gmail.com

Abstract. Currently, around the world there is an acute question of the new energy sources’ development and implementation. It is known that the most significant of them today are oil, natural gas, coal, electricity. Oil and gas reserves are not unlimited. It is necessary to look for the alternative sources of energy [4, 5, 6, 14]. This is due not only to a shortage of basic energy resources, but to the increasing cost of their extraction and processing, as well as to an aggravation of the environmental situation in the world [1]. In search of the new sources of energy, people are increasingly turning to solar panels. This is an excellent replacement for the generators of various types, some of which may be slightly functional or potentially dangerous for a private house. The solar energy has been known for a long time, it is a subject of debate and discussion among the specialists. Some people think that this is a great prospect for the future, others are sure of the opposite, since on the one hand, solar panels do not require expenses for their operation, but the cost of this equipment is high. Some experts claim that the profit from this project will not be able to cover the costs associated with construction. In contrast, these devices can work for tens and hundreds of years, therefore, with long-term operation, the profit will be obvious [4, 5, 6, 11, 14].

Introduction

The idea of creating a business in the Sun has great prospects in the future, because it is an almost inexhaustible source of energy that can be easily used in everyday life. It is also worth noting the versatility and environmental friendliness of this technology, since the solar battery is a device that directly converts solar energy into direct electric current, without unnecessary emissions and environmental impacts, and ecology today is one of the main problems of mankind [2, 3]. Oil and gas reserves are limited; therefore, it is necessary to look for the alternative energy sources. This is due not only to the lack of key energy resources, but to the increasing cost of their extraction and processing. Solar energy has long been known. It is believed that this is the most important direction of energy development in the future. Solar installations are relatively easy to prepare for the operation, while they are quite cheap in its process, and also these devices can work for a large number of years.

Main part

Considering the prospects for the solar energy development in homebuilding, it is necessary to note that the constant increase in prices for the existing traditional energy sources, as well as for electric energy generated mainly as a result of burning fossil fuels, is mainly associated with an increase in the
cost of extracting such fuel and an increase in the cost of its transportation to the place of consumption. At the same time, there is a steady tendency to reduce the cost of energy received from the renewable sources. The use of various concentrators in existing solar installations makes it possible to significantly increase the temperature of the used coolant during thermal energy conversion. In turn, during photovoltaic conversion, concentrators can increase efficiency and reduce the number of expensive solar cells. Concentrating systems operating at high and medium concentrations should have effective tracking systems, which inevitably leads to a significant increase in the cost of the entire structure, complicating the process of its operation, and, consequently, reducing the operation reliability. The use of stationary concentrators with secondary reflector systems in the form of linear and angular heliostats allows improving the technical and economic indicators of the solar system.

The intensification of the using solar energy process in power plants is of interest both to autonomous and remote consumers in the form of separate small housing projects in villages, farms and detached buildings, and for the large-scale solar power plants, the use of which is appropriate both for solving the regional energy problems, and the global energy issues.

It should also be noted that the ongoing depletion of natural resource potential, which creates the basis for the ever wider use of solar energy, allows setting not only economic, but also environmental goals. Due to the inexhaustible flow of solar energy constantly coming to the Earth’s surface, this energy source is naturally replenished. Therefore, when studying the efficiency of using the solar photovoltaic plants, not only economic factors contributing to a reduction in energy costs should always be considered, but also the environmental factors that influence the environmental pollution reduction during electricity generation. Moreover, it is important that Russia as a whole has significant resources for the solar energy development. From the environmental and economic points of view, the active use of solar resources leads to a multiplier effect in relation to:

- increased funding for research on the accounting of alternative renewable energy resources;
- creating conditions for uninterrupted electricity and heat supply to the population and enterprises;
- development of autonomous energy systems using the potential of naturally occurring solar renewable energy;
- make up for the shortcomings of traditional types of fuel and energy complex and reduce the volume of fossil fuels supplied to hard-to-reach parts of the region;
- power supply of decentralized settlements and industrial facilities [10].

From the environmental and economic points of view, the most important factor creating the prerequisites for the active use of the solar resource potential is the presence of a significant number of electricity consumers outside the centralized energy supply systems. The production of portable autonomous power plants of high power at the same time represents a solution to the question of the energy sources’ optimality for hard-to-reach areas where there is no power lines network.

In addition, it should be borne in mind that increasing tariffs for electricity and fuels and lubricants creates high costs for servicing gasoline and diesel generators that supply autonomous consumers. And also, there are massive emissions of combustion products into the environment and a high level of noise [10].

The solar sector is recognized as the fastest growing. The annual increase in capacity of electric solar stations is an average of 50%. Already today, solar energy is able to provide in the region of 3% of the humanity’s global electricity demand. According to the scientists, by 2050 the solar energy market will be able to cover 20-25% of global electricity needs. In addition, it is very important to note that there is a decrease in the solar electricity cost. Every year, electricity from the Sun becomes more accessible by about 4%. According to the scientists, by 2030 the cost of solar and thermal energy will be have been equal, which will allow to start the mass implementation of projects for the construction of solar power plants (SPP).

The energy accumulated in the batteries can be used for direct power supply of devices and equipment, as well as stored for use in case of blackouts or if necessary. The advantage of such plants
is that they can operate all year round. Solar panels are an inexhaustible source of energy that can be easily used in everyday life and in production. The principle of operation of such batteries is based on the conversion of solar energy (free) to electric current (paid). In this way, savings occur [7, 8].

The main areas of application of solar panels may be.

1. New construction. The company offers the construction companies the services of installing solar power plants at the beginning of the houses and apartments building process. This is very beneficial for construction companies both to increase the category of houses and apartments, as well as to increase the reputation of the company in society.

2. The use of solar panels in the reconstruction of houses and apartments. Currently, the active reconstruction of old houses and their conversion into luxury housing with a very high price for 1 m².

3. Construction of country houses. The construction of cottages has become one of the modern areas of construction. Since laying new electric networks can take a lot of time and very high costs, it is more advisable to install solar panels on the roof of a country house that will supply the house with electricity and, depending on the power of the panels, heat it.

Foreign countries have long and successfully used solar energy for life and use the idea of solar collectors as a business. This energy is environmentally friendly and safe fuel, solar panels are mounted on any building, and after the expiration date they are easily replaced with the new ones. The leader in the production of solar cells is, of course, China. For many years, the company from China, Yingli, has remained the industry leader. The closest competitor to this brand is US firm First Solar. Developing countries are not yet at risk of launching their own products on the solar market. It is all about the highest level of competition. There are practically no alternatives to Chinese and American batteries today. Their products are cheaper and of better quality.

In Russia, this fact is taken into account when conducting tenders for the purchase of equipment. National procurement services like Prozoro always thaw the preference for the cheapest and high-quality products.

However, in a number of segments of this sector in Russia, nevertheless, there is an active development. It should be noted the following products of domestic companies in the solar industry.

1. Panels from Telecom-STV (Table 1). The Russian company Telecom-STV (Zelenograd) produces products on average 30% cheaper than the German counterparts: prices start at 5,600 rubles. for the panels at 100 watts. The panels of this manufacturer have an efficiency of up to 20-21%. The main “feature” of this enterprise was the patented technology for the manufacture of silicon wafers with a diameter of up to 15 mm and solar modules based on them.

Table 1. Comparison of solar panels from the company “Telecom-STV”.

| Model   | Power, W | Dimensions, mm   | Weight, kg | Price, rub |
|---------|----------|------------------|------------|------------|
| TCM-15  | 18       | 430x232x43       | 1.45       | starting with 3500 |
| TCM-40  | 44       | 620x540x43       | 4.05       | starting with 6000 |
| TCM-50  | 48       | 620x540x43       | 4.05       | starting with 6575 |
| TCM-80A | 80       | 773x676x43       | 6.7        | starting with 8500 |
| TCM-80B | 80       | 773x676x43       | 6.7        | starting with 9000 |
| TCM-95A | 98       | 1183x563x43      | 7.9        | starting with 10750 |
| TCM-95B | 98       | 1183x563x43      | 7.9        | starting with 11000 |
| TCM-110A| 115      | 1050x665x43      | 8.8        | starting with 12500 |
2. Panel of the Hevel Group of Companies (Table 2). One of the largest manufacturers of solar panels in Russia is the Hevel Group of Companies. In 2017, the company modernized production and switched from thin-film to a new heterostructure technology for the manufacture of solar modules. The modules of the new generation combine the advantages of thin-film and crystalline technologies, provide the efficient operation of the module at high and low temperatures (from -50 °C till +85°C), as well as in ambient light. The average solar module efficiency is 20%. According to this indicator, the modules of the Hevel Group of Companies are included in the world top three. Module service life is at least 25 years.

**Table 2.** Technical and physical indicators of solar panels from the company “Hevel”.

| Technical and physical characteristics | Length | Width | Weight | Open circuit voltage | Voltage at rated power | Rated peak power |
|----------------------------------------|--------|-------|--------|----------------------|-----------------------|-----------------|
| Length                                 | 1671 [mm] | 1002 [mm] | 19 [kg] | 43,5 [V] | 39,2 [V] | 300 [W], 310 [W], 315 [W] |

3. Panels of the Krasnodar “Saturn” (Table 3). Kuban production panels have been produced since 1971, during this period the company produced more than 20,000 m² products. Saturn uses two well-mastered production technologies: based on single-crystal grown silicon and gallium arsenide with a germanium substrate. The latter show the highest possible characteristics and are used to supply the responsible facilities (gas stations, continuous cycle enterprises, etc.).

**Table 3.** Characteristics of the solar panels produced by the company "Saturn".

| Characteristics                      | Silicon | Gallium arsenide |
|--------------------------------------|---------|------------------|
| Short circuit current density, mA / cm² | up to 46 | 16.8 in total (the less the better) |
| Efficiency, %                        | 15      | 28               |
| Maximum power voltage, V             | 0,52    | 2,371            |
| Open circuit voltage, V              | 0,61-0,63 | 2,6              |
| Maximum power, W/m²                  | 211     | 381              |
| Current at the point of maximum power, mA / cm² | 44      | 16,1             |

4. Autonomous systems of street lightening of the Termotron plant (Bryansk). The Thermotron company produces autonomous solar-powered street lighting systems (Table 4) and mini-autonomous solar stations. The first are delivered on the basis of serial modules with high pole support. Autonomous station “Ecotherm”, produced by the plant, will be interesting to the owners of country houses and land. It is also used on farms, telephone exchanges, to equip rural schools, hospitals, shops [9]. The station is powered by a 14.5 kW diesel generator. The price of generated energy with the number of 18 photo processing elements is 5.12 rubles / kW.

**Table 4.** Characteristics of the solar panels produced by the plant “Thermotron”.

| Option | Station power, [kW] | Capacity BC, [A/h] |
|--------|---------------------|-------------------|
Solar energy is not just a promising industry. This market segment is on a par with hydrogen energy. It is to these industries that the scientists assign a leading role in shaping the face of future technologies.

Table 5. Comparison of prices of different firms for solar power plants, rub.

| Power W | Size mm       | Telecom-STV | “Hevel” GC | “Saturn” | “Thermotron” |
|---------|---------------|-------------|------------|----------|-------------|
| 18      | 430x232x43    | 3500        | 3700       | 3300     | 3000        |
| 44      | 620x540x43    | 6000        | 6500       | 5700     | 5000        |
| 48      | 620x540x43    | 6500        | 7000       | 6500     | 6300        |
| 80      | 773x676x43    | 8500        | 9000       | 8700     | 8000        |
| 98      | 1183x563x43   | 10750       | 11000      | 10500    | 10500       |
| 115     | 1050x665x43   | 12500       | 12700      | 12500    | 12000       |

Based on all of the above-mentioned, it can be concluded that the purchase and installation of SPP in the Russian Federation is not so expensive, once installed and launched SPP will make it possible to forget about utility bills for many years.

Let us consider the effectiveness of solar panels for heating a private house. Electricity is an excellent source of heat. For example, many houses in Europe now have just this heating system. It is necessary to take into account the fact that it is advisable to organize heating of a private house with the help of such a source only for regions with a maximum of solar energy. For the northern territories, a slightly different approach will be required. In this case, it is recommended to combine the use of solar energy with other types of heating. The thing is that the efficiency of such batteries in cloudy weather decreases, so it is necessary to take into account the fact that the sun does not shine all the time, the solar panels can be covered with snow in the winter, can be obscured by tall trees and so on, which can cause a lack of heat. Therefore, heating using solar energy converted into electrical energy is not recommended for use in the northern regions.

Let us consider cost-effectiveness. An important point when using this source is the economic benefit. It directly depends on the battery power and the area of the photovoltaic cells that receive the rays. If to take an example of a city like Moscow, it is possible to get the following interesting data. If to install a device with a capacity of 13.5 kW, it almost completely replaces electricity, which can ensure constant heating of the house in all months of the year, with the exception of November, December and January. At this time, it is possible to leave the main devices to work from the solar devices, and connect the heating to the central system. So, pretty well save can be possible. The most powerful generators are those with a power of 31.5 kW. They will completely abandon the main types of energy supply and use only solar energy throughout the year for a long time.

The benefits of an energy source. The electricity obtained this way is an alternative to the one we are used to using today. This type of energy supply is optimal for those territories and objects where there are no other sources of electricity, and can also be indispensable in the southern regions of our
country, where there is a peak in solar activity. When using these stations, it is important to remember that they can last for tens and hundreds of years and save a lot of money [12, 13].

**Summary**

Based on all of the above-said, we conclude the following. When installing an alternative source of electricity, it is worth considering that the effectiveness of such equipment depends on several factors. The most important of these is solar energy activity and battery power. The most optimal are the devices with a capacity of 13.5 kW or more, which can ensure almost uninterrupted operation of all equipment. For the northern regions of our country, the use of batteries is not promising. Their use as an additional source of electricity is recommended in order to save money. When constructing solar stations, it is necessary to consider the cost of equipment, but the payback will be quick.

**References**

[1] Bondarenko S V, Takhumova O V 2019 Economic and organizational mechanisms of forming business networks in the construction industry *IOP Conf. Ser.: Mater. Sci. Eng.* 698 077040

[2] Gura D, Dubenko Y, Markovskiy I, Pshidatok S 2019 Monitoring infrastructure facilities of territories in agricultural sector *IOP Conference Series: Earth and Environmental Science* 403 (1) 012185. doi: 10.1088/1755-1315/403/1/012185

[3] Gura D, Kuzyakina M, Gribkova I 2019 Assessment of bioclimatic comfort of the Krasnodar Krai *IOP Conference Series: Earth and Environmental Science* 403 (1) 012176. doi: 10.1088/1755-1315/403/1/012176.

[4] Takhumova Oksana V, Kadyrov Marsel A, Titova Evgenia V, Ushakov Denis S, and Ermilova Mariia I 2018 Capital Structure Optimization in Russian Companies: Problems and Solutions *Journal of Applied Economics Sciences* XIII (7)(61) 1939-1945.

[5] Popov R A, Sekisova A N, Shipilova N A 2016 The Economics of Innovation in Modern Russia: Practice, Problems and Prospects Prospects *International Journal of Economics and Financial Issues* 6 (8) 184-188. Information on https://www.econjournals.com/index.php/ijefi/article/view/3727/pdf.

[6] Popov R A, Shipilova N A, Sekisov A N, Soloveva E V, Gura D A 2019 Innovative development of construction in russia: economics, technologies, management *Amazonia Investigata* 8 (19) 653-663 (Information on https://amazoniainvestiga.info/index.php/amazonia/article/view/281/258).

[7] Sekisov A N 2019 Improving the efficiency of the organization of construction production based on the use of BIM-technologies *IOP Conference Series: Materials Science and Engineering* 698 066005. Information on https://iopscience.iop.org/article/10.1088/1757-899X/698/6/066005/pdf. doi:10.1088/1757-899X/698/6/066005.

[8] Solovyova E V, Sekisov A N, Gura D A, Mikheev G V, Koztunenko M G 2020 Developing Optimization Modelling Methodology for Production Costs Generation *Helix, Singapore* 10 (2) 63-71. Information on http://helixscientific.pub/index.php/Home/article/view/112/112.

[9] Volkov A N, Leonova A N, Karpanina E N, Gura D A 2017 Energy performance and energy saving of life-support systems in educational institutions *Journal of fundamental and applied sciences* 9 (SI 2). doi: 10.4314/jfas.v9i2s.69.

[10] DavydoS I 2018 Research on the efficiency of using a solar photovoltaic station in the Amur Region for the power supply of autonomous consumers *Young Scientists* 21 (207) 38-40.

[11] Ovchinnikova S V, Gorchakov A O 2019 Analysis and development prospects of prefabricated buildings and structures. Modern equipment and technologies: research, development and their use in the comprehensive training of specialists *Materials of the VIII scientific and practical conference, Nevinnomyssk, SAEI SNGTI* 79-82.

[12] Solovyova E V, Sekisov A N, Furman N A 2018 Outsourcing and insourcing in construction organizations: advantages and disadvantages *Economics and entrepreneurship* 11 (100) 1168-1171.
[13] Ufmitsev F R, Sekisov A N 1998 Problems of improving the organization of production processes In the collection: Problems and prospects of Russian management on the threshold of the 21st century Southern Institute of Management, Kuban State Technological University, Academy of Science and Practice of Organization of Production (Krasnodar Department) 56-59.

[14] Khalilov E N 2012 Global environmental changes: a threat to the development of civilization Natural and technological risks. Safety of facilities 1 22-47.