

Modern prospects of development of branch of solar power

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Abstract. Advantages of solar energy for modern companies are evident already. Article describes mechanism of the solar electricity generation. Process of production of solar modules with appliance of the modern technologies of sun energy production. The branch of solar energy "green energy" become advanced in Russia and has a stable demand. Classification of investments on the different stages of construction projects of solar power plants and calculation of their economic efficiency. Studying of introduction of these technologies allows to estimate the modern prospects of development of branch of solar power.

1. Introduction

Accessible inexhaustible sources of energy for the modern mankind. Advantages of solar energy are obvious:

- Solar energy is infinite. Sun, being in the middle of its life cycle, will be active for billions of years.
- The amount of solar energy is huge. Within 20 minutes sun sends to earth as much energy as the entire population of the earth can consume during a year.
- Methods of production of the solar energy on a traditional basis and its delivery to the end user are extremely inefficient. Losses reach 80%.
- Solar energy is available almost everywhere. And the way of its generation assumes minimal losses during delivery, since its production and usage are possible in the same place. Modern mass production of solar cells has already reached indicators with 20% efficiency [1].
- Si - silicon is one of the main semiconductor elements used in the manufacture of modern photoconverters. Silicon has the second place after oxygen in the relevance through the abundance in the earth's crust. Traditional sources of energy as hydrocarbons (coal, gas, oil) are finite, and their reserves are wasting year after year.
- Generation of solar energy through phototransduction, is absolutely environmentally friendly process. No emissions of carbon dioxide are produced, no nuclear waste is produced and environment is not polluted.
- Nowadays, in many parts of the world solar energy is becoming cheaper than energy from traditional sources. Especially if all the losses of traditional energetics processes are taken into consideration, costs for compensation for the limitation of greenhouse gas emissions, costs for reclamation of the nuclear wastes.
- In its latest study, Sarasin Bank tells about the enormous potential of solar energy and notes the achievement of parity (equality) of prices between the traditional and alternative energy in certain regions here and now, and predicts the huge potential of this industry in the next 5 years [2].
- Solar energy, as one of the alternative sources, becomes the only available and effective source



for many territories (fringe and underpopulated areas, economically underdeveloped areas), to which the delivery of traditional electricity is inexpedient and too expensive.

- Solar energy allows to be energy-independent: to receive qualitative electricity regardless from quality of existing power grids.

- Solar energy development programs which involve the payment of preferences for owners of solar systems are foreseen in many countries.

- Solar energy applies in the many modern companies all over the world and in Russia. This includes the private sector, business and state companies. Farms, tourist camps, suburban areas, motorway filling stations, private houses and cottages are spectacular example of small and medium business.

The purpose of the real research consisted in considering the mechanism of modern technologies of solar generation of the electric power. Results of a research have shown that investment into solar power is profitable.

2. Materials and Methods

In Russia the law on renewable energy was adopted in 2010, but its real application in the industrial scale is expected in the near future. Nowadays, network companies are already obliged to develop and adopt loss compensation programs during the delivery of electricity from alternative, renewable energy sources.

Issues of energy efficiency and independence are being solved during the installation their own solar energy generation system and "emission-free energy" is also being produced, protection of the environment is being performed, and mineral resources are preserved. Solar power generation is an investment in your future and the future of your children.

The forecast of the International Energy Agency (IEA) shows the tendency of changing of the world energy balance structure in the direction of energy efficiency growth, increase of the usage of renewable energy sources (RES), wider application of modern technologies for CO₂ capture, and change-over to new fuels in transport. These change allow to diversify the fuel and energy complexes of countries and to reduce greenhouse gas emissions significantly.

Solar energy can become a generator of renewed economic growth, such as the steam engine, car, computer. Conversion of solar energy into electrical energy is performed in the photoelectric transducers (PT). Depending on the material, construction and method of production, it is done to distinguish three generations of PT:

- First-generation PT on the basis of crystalline silicon wafers;
- Second-generation PT on the basis of thin films;
- Third-generation PT on the basis of organic and inorganic materials.

The most common technology is the production of PT on the basis of crystalline silicon. This technology accounts 85-90% of all solar systems.

Crystalline silicon technology is leading and is considered below. The process of solar modules manufacture consists of several stages.

First stage is the production of polysilicon (contains 99.9999% Si) from silicon containing inorganic compounds (i.e. trichlorosilane). This is the beginning of the big and complex technological chain in the creation of solar module and solar cell.

The second stage is growth of ingots of crystal silicon in special furnaces in different ways. Basic mass technologies:

- (A) single crystal growth according to the Czochralski method;
- (B) growing multicrystals according to the method of directional crystallization. Existence of different technological approaches is justified with the struggle of two eternal directions: (A) perfection of the crystal structure and high effectiveness of solar cell, and (B) maximum performance (ingots up to 1 ton versus 200-300 kg for monosilicon), with slightly lower efficiency of solar cells. Current difference in the efficiency of solar cells for mono and multi-technology is equal to no more than 1-2 percent.

At the third stage grown ingots are passed through the mechanical processing (squaring, grinding)

and resulting of such processing square columns are cut on thin plates (180-200 microns) with the help of wire cutting machines.

The fourth stage is the process of the creation of solar cell from the crystal plate (mass form factor 156 mm x 156 mm x 200 micron).

Plates obtained in the process of cutting of silicon ingots are cleaned of traces of cut. Damaged layer is removed from the surface of the plate through the chemical etching. Selective chemical etching is performed on the surface of the plate using special property of the crystal structure to create so-called textured surface for significant increase of the surface area, and thus to increase the absorption of light by the solar cell. p/n junction is created through the phosphorus diffusion for creation of a future electric circuit of the solar cell. Then layer of phosphorous glass, which was created with diffusion is removed and layer of an antireflection coating, which reduces the optical losses and ensures the electrical passivation of the created layer, is applied. Then comes metallic coating. It means the application of current-collecting tracks, face of the plate with the silver and the back surface. Finally, the finished element is examined throughout all electrophysical parameters and effectiveness. Process of manufacture of solar cells is advanced. This is the concentration of the most advanced technologies and developments.

At the final fifth stage solar cells are connected to the solar module at the frame. Module build process is fully automated. Elements in the chain are soldering or "threads", which are connected into a matrix consisting, for example, of 60 solar cells for a standard 200-250 watt module. Then matrix is placed under a layer of glass and 3 films, which are laminated in a vacuum oven with the temperature of 160 °C and solar module acquires tightness and resistance to various weather conditions thanks to this. After establishment of the connectors for connection, the module is placed in a solid aluminum frame. Final stage of the module assembly process is the control measurement of the module's operation under the test conditions [3].

3. Results

When sunlight reaches FEP or solar element, photons of light, colliding with silicon atoms, are transmitting the part of the energy and arouse electrons. Released electrons rush to the negative electrode which was created by the p/n transition. As a result, electricity dynamic is generated for the external load supply.

Amount of generated electricity depends on the duration and intensity of solar radiance directed at the solar cell. The quantity of solar radiation on a horizontal surface varies from 500 to 2500 kV / h / m², depending on the geographical location and time of year. Besides, orientation of the solar cell and solar module in relation to the sunlight affects on the generation of electricity. Namely, slope of the solar module and its direction in azimuth.

There are two main types of solar systems, depending on their connection to exterior electrical network - off-grid and on-grid.

Autonomous Systems, in turn, are divided into autonomous direct current systems and autonomous alternating-current systems. Produced direct current is used for power supply load at once in autonomous direct current solar systems. Excess power is stored in accumulator battery, charging rate of which is controlled with the charge controller. These systems are applied in campings, wagons, on the water sports equipment, farms or for remote telecommunications installations powering (DC).

Autonomous alternate current system includes inverter (DC / AC converter). This is an additional element which converts DC to AC for ensuring of the necessary frequency and voltage characteristics for an AC load.

Autonomous/reserve solar system is effective when:

- the possibility to obtain electricity from an external network is either impossible or extremely expensive;
- power supply from external networks is unsatisfactory and has failures.

Network solar systems compose the basis of solar energy in the world. They assume sale of the generated solar electricity to external networks with the special (in many cases, premium tariff - feed in

tariff). Installation of two metering instruments is provided for the private households in Europe, the United States, China, Japan, South Korea and many countries of South-East Asia, in part of the countries of the South America. One is for consumption from an external network, another is for the sale of generated solar energy to external networks. At that, construction of network systems can be different: and with "priority for usage" of generated solar energy, and completely stand-alone systems "for sale only". Creation of the hybrid generation systems which consist of different energy sources as solar electricity, wind turbines, diesel generators and others is also possible [4].

Nowadays there is an experience of creation of the Russian investment company which manages investment funds and acts as "Developer" in the series of projects on creation of the solar power plants on the territory of Italy and Germany.

Investment company is responsible for:

- finding and purchase/rent of the project sites;
- development of designing estimates;
- attraction of financing from European banks;
- attraction of financing from investors;
- purchase of equipment (solar panels, construction materials, electrics/electronics);
- connection of the complete station to the network;
- management of power plants after commissioning;
- finding a buyer for the possible withdrawal from the project.

Calculation of economic efficiency of investments in the solar energy on the example of the roof of industrial building (Table 1).

Table 1. Economic efficiency of investments in power plant

Location	Size of the site, sq. m	Station capacity, KW	Annual performance, MW/h	Annual revenue Euro	Payback period, years
Italy	8000	980	1.25	390,000	6.13

Contract with power companies on the electricity supplement is concluded on 21 year in condition of implementation of legislation on the development of solar energy in Italy. As a result, this project can be considered effective and the revenue for 21 year amounts 7 371 000 euros, taking into consideration that efficiency of solar element declines in the process of exploitation (coefficient 0.9 is taken, although the producers of modules guarantee degradation on the 10% after the 10 years and on the 20% after the 20 years).

4. Discussion

The complex of regulatory acts aimed at the development of renewable power generation was approved at the Government meeting on May 23, 2013 in Russia. According to the new program, incremental capacities of renewable sources must have almost 6 GW to 2020. Decision on creation of the first solar parks (large solar power stations) was also accepted. According to the accepted measures, share of the renewable power generation in the power balance of the country should rise from the current value of 0.8% to 2.5% in 2020 [5, 6].

Main requirements for participation in the program are the localization of production of components and equipment for power plants with renewable energy sources on the territory of the Russian Federation. Now the degree of localization is about 20%, but in 2020 this value will increase to 70% as a result of the realization of the program. Approved by the program incentive mechanism is long-term contracts (15 years from the date of commissioning of the facility) for purchase of capacity, which ensure a payback guarantee due to increased payment (guaranteed return and investment amounts 14%). It is assumed to hold annual competitions, the first competitions were held in autumn 2013.

5. Conclusions

Despite the fact that companies in the field of solar energy had some hard times, this industry continues

to evolve:

- Demand for solar energy reached a record annual value of 29GW;
- The total capacity of accumulated installed capacity of solar generation exceeded 100 GW;
- Becoming more "affordable", solar energy opened new markets, such as the Middle East, Africa, Latin America, Southeast Asia;
- Average price for solar modules fell below the \$ 1 / W mark, and, accordingly, the cost of solar systems decreased in such a way that discussions on the achievement of the price parity become reality (even without the government support).

Undertaken study of the Solarbuzz company foresees further preservation of solar energy rates of growth. So, according to the research, the power of solar energy over the last five years from 2013 to 2017 has increased to 230 GW. Almost half of this value falls on large-scale solar electric plants installed on the ground [4]. After 2020 North America, China and India will become leaders of the solar market. In the long term network energy consumption will dominate in the developed markets.

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