SOLAR ENERGY IN UKRAINE

Hovorov Pylyp Paramonovich
O. M. Beketov National University of Urban Economy in Kharkiv

Hovorov Vladlen Pylypovich
O. M. Beketov National University of Urban Economy in Kharkiv

Kindinova Anastasiya Kostyantynivna
O. M. Beketov National University of Urban Economy in Kharkiv.

Annotation

An assessment of the state of the solar energy of Ukraine and its prospects is given. The problems of solar energy are considered and solutions are given.

Keywords: solar energy, prospects of solar energy, problems of solar energy.

INTRODUCTION

The geography of Ukraine opens up a great potential for the development of market solar energy.

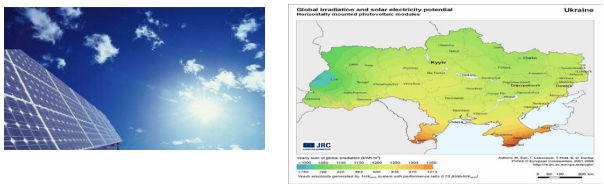

Fig. 1. *The possibilities of solar energy in Ukraine*

The possibility of using sunlight increases in the direction from the northwest (1070 kW / m^2) to the southeast (1440 kW / m^2) with the highest potential remains the Crimean peninsula. The period of effective use of solar collectors in the southern regions of Ukraine is 7 months (from April to October), in the northern regions - 5 months (from May to September). Although, in general, photovoltaic equipment can work effectively throughout the year, but with slightly worse characteristics. For example, solar collectors for heating water are already widely used in southern Ukraine, and during the year.

According to the National Agency for Energy Conservation and Energy (ANME) [1], the potential of solar energy in Ukraine is much higher than in Germany, and it is technically possible that the share of solar energy will reach 10% of Ukraine's energy balance by 2030, despite the fact that equipment for producing solar energy is still quite expensive. A strong tendency to reduce the cost of its production, which is observed in the modern world, is that demand has increased, and progress has played a significant role, which means cheaper structures and increasing their efficiency. According to the EBRD, Ukraine may become a leader in the near future including a green economy in Europe, especially with regard to market solar energy, which is one of the most promising renewable energy markets. Currently, Ukraine already operates the largest solar power station in Europe, and it is planned that the solar energy market in Ukraine will grow annually by 90% by 2020.

EXPOSITION

The rapid development of the renewable energy market in Ukraine in recent years contributes to the fact that a certain number of small and medium-sized players in the solar energy market began their activities in Ukraine. Taking into account the existence of many problems that must be overcome, the huge potential of solar photovoltaic projects with a capacity of 1-10 MW and actively contribute to the growth of the market, the introduction of equal conditions for all stakeholders,

transparency in the energy sector and the creation of a more stable investment climate.

At the end of 2016, the structure of Ukraine's generating capacity was as follows (in percent, indicated in brackets by the installed capacity at power plants): CHP and CHP - 57.5% (25472 MW) NPP - 29.6% (13107 MW) HPP and SRP (pumped storage power plants) - 12.4% (5500 MW). Solar ES - 0.3% (MW 130) windmills ES - 0.2% (86 MW).

However, the factory coefficient of Ukrainian thermal power plants is much lower than that of nuclear power. The actual electricity production in Ukraine in 2010 in the framework of the United Energy System. TPP TPP and 45.7% (87.01 TWh) nuclear power plants 44.6% (84.9 TWh) hydroelectric power station and PSP (power plants with pumping) 5.1% (9.6 TWh).

Fig. 2. *The structure of the installed capacities in Ukraine*

Table 2. The energy potential of Ukrain

Installed mo generality power plant ECO Ukraina, MW generation type			
Year	*2009*	*2010*	*Growth,%*
CHP generating company	*27257*	*27347*	*0,3*
NPP	*13835*	*13835*	*0*
TPP and other thermal power plants	*6368,3*	*6426,9*	*0,9*
HPP	*4552*	*4596,9*	*1*
GAES	*861,5*	*861,5*	*0*
Wind power plant (WPP)	*83,9*	*86,2*	*2,7*
Solar power (SES)	*0*	*8,1*	*100*

The market for renewable energy in Ukraine looks quite promising, especially with the adoption of a tariff tariff that stimulates the development of solar energy. This indicator is one of the highest in Europe. It was introduced in Ukraine in 2009 as an incentive for the use of alternative energy sources and should function until 2030. During this time, the state should power companies to connect alternative energy to the network. The rate is pegged to the euro in order to protect foreign investors from fluctuations in local currency. The green tariff is regulated monthly by the National Commission for Regulation of Ukraine (NERC). In October 2011, the tariff for the production of solar energy amounted to 0.465 Euro / kWh. Since the adoption of the law in May 2011, Ukraine has been granted only 45 such exceptions.

One of the government's priorities in the field of electric power is a market transformation to eliminate the wholesale market of interaction between producers and distributors, which made it possible to directly conclude transactions for the supply of electricity to consumers. However, the final result of the reform in the wholesale electricity market may be unattractive for companies willing to operate at "green tariffs", since only the wholesale market provides the state with the only mechanism for buying alternative energy based on tariff. To ensure the implementation of the project tariff, the law establishes that the obligation of the state to buy a green tariff for alternative energy will be distributed after the implementation of the reform in life. However, if the wholesale energy of the market is eradicated, it is unclear how the green rate will be implemented. In general, it was assumed that the "green" tariff will become the main instrument for implementing a targeted program to improve economic efficiency and renewable energy and energy development in 2010-2015.

Another problem is the so-called "local components". According to the law, from January 1, 2012, the share of raw materials, installations and equipment, works and services of Ukrainian origin in the cost of construction of a corresponding power plant operating from alternative energy sources must be at least 15%. On January 1, 2013, in order to receive a "green tariff" for electricity generated using sunlight, we must use Ukrainian raw materials stocks with the solar modules in at least 30% of the production cost of components And at least 50% starting January 1 2014 However, the exact procedure for determining the Ukrainian

component is still being developed by the National Electricity Regulatory Commission of Ukraine (NERC).

The new tax code, which was adopted in December 2010, aims to create favorable conditions for the boom of "green" energy. It implies exemption from income tax on profits from electricity generated from renewable sources until 2020. According to Article 158 of the Tax Code, 50% of the profits from energy-saving operations and the implementation of projects on energy-saving projects included in the State Agency for Energy Efficiency and Energy (NAER) will be exempt from income tax. However, this procedure did not come into force, as the list includes only two companies NAEP: OJSC Semiconductor Plant (a subsidiary of Activ Solar) and Kvazar JSC (Kiev). Producers will have to invest funds obtained as a result of such benefits, targeted programs, which are quite difficult to control. In addition, in July 2010, the Parliament adopted the Law "On Land for Power Plants and the Legal Regime for Special Zones of Energy Facilities", according to which the rent for renewable energy sources was reduced by 70%.

Since the import of equipment for the production of solar energy is the most expedient and less expensive for the construction of plants operating on solar energy, it still creates problems with the discovery of investors. In accordance with the new Tax Code, which was introduced in 2011, other benefits applicable to the development of renewable energy sources include duty-import and exemption from value added tax, provided that the relevant products are not produced in Ukraine. However, the importer's import must go through a process of approval at the Ministry of Economic Development and Trade, which, at the suggestion of the central executive authorities, must write a draft decision, which will be adopted by the Cabinet of Ministers of Ukraine on the introduction of appropriate amendments to the list of equipment that should be exempted from import duties and VAT, and the inclusion of this particular list of equipment and properly send the decision to the Cabinet of Ministers of Ukraine, which will take such a special decision ix.

Electricity network: relevant legislation regarding the electricity network: relevant legislation regarding the electricity network: the relevant legislation concerning the connection systems for the production of solar energy to the network is not in place. An issue that should be resolved at the closest

the future relates to the development of a general procedure for compensation. The costs incurred by the investor in the construction or modernization of those parts of the electrical network, which will be transferred to network operators. The period of 20-25 years, during which it is proposed to reimburse the costs of installation, is not justified. NERC should develop and adopt a unified procedure for connecting solar power plants to the grid and allow costs to be incurred for the approval of investment programs of local operators. In addition, the lack of practical experience in technical documentation for the preparation of systems for connecting PV to the network (photovoltaics) is also an obstacle.

Poor project design: having a well-prepared, low-income project: having a well-trained, low-income project: having well-prepared projects is a priority condition that precedes market development; But another problem in Ukraine with respect to renewable energy sources is the lack of a "western" approach to project preparation. According to the experience of the EBRD, about 30% of local project developers are unprepared projects or cannot provide adequate funding. In addition, there is a lack of knowledge about such parameters as cash flow, net present value, payback period and overall project management. Many applications are based on unreasonable, non-commercial technologies.

Infrastructure: we are talking about investment and the development of a new sector. Speaking of investment and development of the new sector, it is worth mentioning the financial infrastructure that is used to facilitate this process. Until now, Ukrainian banks have been reluctant to support projects on the basis of financing schemes for projects that they usually use to work with the corporate sector by offering simple loans

against collateral. Consequently, the specific time it takes for banks and project managers to reach agreements in this market. Currently, the Bank is helping to finance such projects, although at least 30% of the project cost. It must be funded from other sources, which is also a particular problem for local developers.

Another problem that may be investors is the lack of public awareness and interest in the prospects for the use of renewable energy sources. proof of this is the fact that 90% of solar modules produced in Ukraine are exported to European countries, but again the reason for this. This is mainly due to the significant absence (until recently) of the solar energy market.

In addition, investors do not believe that the Ukrainian government or the National Electricity Regulatory Commission (NERC), which is the regulator of the local market, clearly understand how the green tariff will function as a system in bilateral agreements and on the balancing market that Ukraine promised before the end of 2014.

Despite laws that provide financial incentives and company holidays, Ukraine sees high potential, a developing market with extremely high investment attractiveness from the point of view of a "green" tariff for solar energy, which forces investors to take risks and find solutions to the difficulties mentioned. Although this segment of alternative energy was stored at the initial stage of development in Ukraine, the country saw a favorable situation for the expansion of the solar energy sector. Without a doubt, the Ukrainian market of solar energy is slowly but surely growing, and very soon there will be positive growth trends.

Active Solar, an international group of companies, having successfully completed the commissioning of a pilot project with a capacity of 7.5 megawatts in the village of Rodnikovoye (Crimea, Simferopol District), Activ Solar announced the completion of the construction of a photoelectric (PV) power plant at 80 Okhotnikov megawatt (MW) (Crimea, Ukraine).

The station is one of the largest on the European continent. This is the largest ground installation ever built in Central and Eastern Europe and the fourth largest in the world among 50 large photovoltaic power plants! The project is divided into four a queue of 20 MW, the first of which was connected to the network in July 2011, and the last, fourth, completed in October 2011. The solar-powered station consists of approximately 360,000 units installed on an area of 160 acres, which is approximately 207 football fields. The station, according to preliminary estimates, will produce 100,000 megawatt-hours of electricity per year to meet the demand for green energy in 20,000 households and to reduce carbon dioxide emissions by 80,000 tons per year.

In November 2011, Activ Solar announced the completion of the third stage of the Perovo solar power station. The third phase, built just a few weeks after the launch of the second, adds an additional 20 megawatts (MW) to the project, with a total capacity of 60 MW today. The 1, 2, and 378,500 megawatt-hours of electricity per year, enough to meet the electricity needs of about 16,500 households, and reduce carbon dioxide emissions by 63,000 tons per year. The ground-based solar installation of all three queues consists of more than 264,000 mono-and multi-crystalline photovoltaic modules 80 and inverter central stations. Construction Perovo continues.

The successful completion and commissioning of the first stage of the solar power station in the southern part of Vinnytsia region in September 2011, Rentehno reported. The rated peak power of the installed equipment is estimated at 250 kW; The PV panels used in the project were manufactured by a company that is among the top five manufacturers in the world. In Europe, inverters were manufactured for solar power plants at the nodes of the merger and cables. The Rentehno company itself developed a technical solution for the station, implemented a selection and organized the supply of equipment. All technical inspection of the installation and commissioning works on the project was carried out by Renestno LLC. The equipment was supplied in cooperation with the Israeli company Sunelectra. Stations of introduction of solar energy in the southern part of Vinnytsia region are divided into several stages. The power of 250 kW of the first phase was implemented and put into operation in

September 2011.

In October, the second stage was installed 321.5 kW; The last part should be put into operation during 2012. Three more PV plants will be built in Vinnytsia region by Rentehno. Current status - development of project documentation. The total capacity of the first 2 projects is 2.6 MW. The construction of the third PV plant will begin in the near future. The expected result is 2 MW.

The company also announced plans to implement a project for the construction of a power station on a solar power capacity of 9 MW in Kherson Square. Current status - project development. The company will be responsible for the design, procurement and construction. Preparation of technical documentation for the project was started in September 2011. The project is divided into several stages, as a result of the commissioning of the first one, 1 MW will be received, and this event is scheduled for the end of March 2012. The plant will be commissioned until the end of 2012.

Another PV project of Rentehno is the installation of 15 MW solar photovoltaic power plants in the Odessa region. The current status is a preliminary feasibility study. The company is responsible for the preparation of project documentation, participation in installation and commissioning. The installation of PV installations will be completed during 2012. The company intends to produce about 11 MW at facilities in Skadovsk and Genichesky district as a design, procurement and construction contractor. Rentehno plans to build several of its own solar power plants, which will be built together with Ukrainian and international investors by the end of 2012. Currently, the company is developing a portfolio of orders for the Crimean land, Kherson, Nikolaev and Vinnytsia regions.

The organization of production of solar modules in Ukraine with an annual capacity of 25 MW is currently in a preliminary feasibility study. These facilities will be created to meet the growing demand for solar modules in Ukraine, taking into account the entry into force on January 1, 2013 of the requirements for a 30 percent share of materials and components of local origin in solar modules.

As evidenced by the results of the inspection, in recent years, Ukraine has been quite intensively increasing the volumes of electrical energy generated at the base (PES) (Fig. 3). Most of the PES is connected to the distribution network. This is due, on the one hand, technical features, and on the other, financial factors. Connecting photovoltaic power plants to distribution networks leads to the fact that these networks acquire the properties of an electrical system with all the advantages and disadvantages. In this case, the distribution electrical networks with sources of distributed generation acquire the properties of local electrical systems (LES).

It should be noted that the development of PES, is uneven within Ukraine. This is due to two reasons - the uneven distribution of the intensity of solar radiation in Ukraine and the uneven distribution of investments in solar energy. So, according to the National Commission implementing state regulation in the fields of energy and utilities (NCREU or NKREKU), at the beginning of 2017 almost a quarter of the power of FES is connected to the networks of Vinnitsaoblenergo (Fig. 3.)

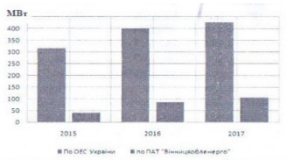

Fig 3. *Increase in installed capacity of PES in recent years (MW): in the United Energy System of Ukraine and PJSC "Vinnitsaoblenergo".*

In 2018, the most powerful solar power station in Europe with a total capacity of 50 MW was commissioned near Zaporozhye. In general, in Ukraine as of May 2018, more than 100 PES of various capacities and accessories were connected to distribution electric networks.

Under these conditions, it is obvious that the distribution of PES across regional networks is also uneven. This leads to the appearance of LES with significant power PES. The percentage of load covered by PES reaches 20% in some areas. Taking into account the peculiarities of such energy sources, the question arises of taking into account their impact on the reliability of electricity supply, in particular the balance sheet, and ensuring the efficiency of power transmission and quality.

The optimal level of reliability of LES corresponds to the minimum value of the reduced cost of reservation BΣ fig. 4.

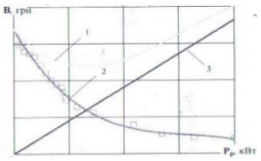

Fig. 4. *Graphical representation of the interrelation of named and relative (probabilistic) indicators of balance reliability in LES 1 - total reserve losses, 2 - dependence of energy supply company for under-utilized electricity, 3 - expenses for maintaining tank capacity.*

The defined reserve capacity corresponds to the minimum reduced cost of the power supply company to ensure the reserve capacity. In fig. 5 shows a fragment of the scheme of Yampolsky RES with PES. In fig. 6 shows how to improve the quality of energy in networks with PES. In fig. 7 shows various ways to improve the balance reliability of PES.

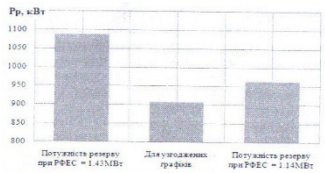

Fig. 5. *Power scheme PES Yampolsky SEM*

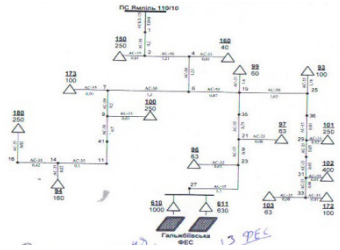

Fig. 6. *Different ways to improve the quality of power LES*

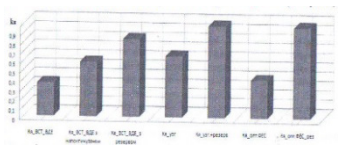

Fig. 7. *Change of reserve capacity for various means of increasing the balance sheet reliability of LES*

A feature of LES based on PES is a high level of distortion in networks.

In fig. 8 shows the results of harmonic components in the voltage on the EU tires, which use controllers operating according to different control laws.

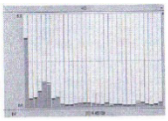

Fig. 8. *Spectrum of harmonic components in voltage on PES tires*

A less harmonic distortion of the sine wave voltage occurs when using a PI controller, realizes the conversion to the abc coordinate system will give the most harmonic distortion at the output of the inverter.

The block diagram of the integration in the ASC with the generation of PES power is shown in fig. 9.

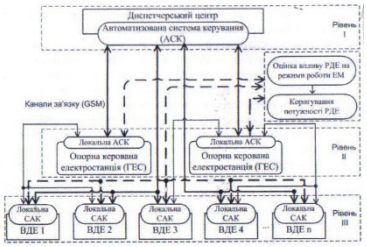

Fig. 9. - *Block diagram of the ASC generated by the power of PES*

Thus, the intensive introduction of photovoltaic stations (PES) into the electric power system of Ukraine indicates the unsuitability of distribution electric networks in photovoltaic stations, with unstable generation and the lack of a sufficient level of network automation.

Placing PES close to consumers should potentially lead to unloading of electrical networks, improving the quality and reliability of electricity supply. However, the instability of the PES generation, which is due to the natural features of their installation site, the overestimated power of the connected source leads to a decrease in the efficiency of the electrical network and a decrease in the quality of power supply services for the end user. This is especially true for PES, whose share in the balance of the United Electric System of Ukraine is large.

Thus, the presence of energy sources in distribution electrical networks allows characterizing them as a local electrical system (LES), the reliable and economical operation of which not only determines the level of electricity supply services, but also the stable operation of the electric power system (EPS). At the same time, it is important to coordinate load schedules and generation of LES in such a way that by balancing the power in LES to minimize their impact on the main centers of power EPS. Especially when, at the points of connection of LES to the EPS, it is necessary to maintain the specified schedule of consumption (generation) of electricity. Under such conditions, minimization of deviations from the centralized given schedule of the cumulative generation of PES can ensure the stability of the LES, both in the minimum load mode and in the maximum load mode.

CONCLUSIONS

Since the share of photovoltaic power plants in Ukraine is significant, and generating them is unstable due to dependence on weather conditions, it is relevant to take into account their influence on the modes of local electrical systems. Under such conditions, it is necessary to ensure the optimal use of PES in electrical networks so that the interests of companies in the generation and distribution of electricity are simultaneously agreed and the quality of electricity supply to consumers is ensured. In addition, analysis of the operating conditions of electrical networks with renewable energy sources, noted the impact of instability of generating renewable energy sources on electricity losses in electrical networks, and the quality of electricity in them, as well as the reliability of electricity supply to consumers.

This makes it technically necessary and economically feasible to represent PES as an element of an EPS and to take into account all their internal and external relations, that is, to provide them with system properties.

NOTES:

[1] - National Agency for Energy Conservation and Energy (ANME).

REFERENCES:

[1] Energy resources that flow. Kiev: Ukrainian encyclopedic knowledge 2003. 472 p.
[2] The basis of the parametric energy dependence of the national economy for the period up to 2020. K .: Viewing. In-electrodynamics of the National Academy of Sciences of Ukraine, 2011. 275 p.
[3] Lezhnyuk P.D. Optimization of Price Application for Electric Station in Conditions of Energy Market, P.D. Lezhnyuk, V.V. Kulyk, V.V. Teptya Nauka i Studia, Przemysl, 2014. 57-65 p.