RES-powered charging stations for electric vehicles

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Abstract. The paper provides a comparative analysis of the structure of energy consumption and production in the countries of the European Union and Russia. It is shown that Russia is a promising country for the effective development and implementation of renewable energy sources. A block diagram of a charging station for electric vehicles, which will be powered by photovoltaic panels, is proposed. Unclaimed electricity in this case can be sold to the external network or smooth the load curve of the nearest transformer substation.

1. Introduction of RES in the EU countries and Russia
At present, the world electric power industry has taken a course to reduce the use of hydrocarbon resources. Generation based on renewable energy sources, such as wind energy, solar energy, geothermal energy, is rapidly developing [1].

The EU is expanding its climate ambitions in a “green course” and aims to become the first climate-neutral continent by 2050. Therefore, the Energy Efficiency Commission decided to review the existing legislation and, if necessary, amend it in order to achieve the target of greenhouse gas emissions for 2030.

Solar energy is a relatively young and promising branch of science and technology. Today, the share of solar energy in the generation of the world electric power industry is 2.6% [2].

Since Russia is a country with large reserves of fossil fuels, the bulk of electricity generation comes from thermal power plants. As of January 2020, the capacity of electricity generated by thermal power plants amounted to almost 67% of the total installed capacity of all power plants in Russia. At the same time, natural gas is used for the most part as fuel. Hard coal is used less often. Blast furnace gas, coke oven gas or associated petroleum gas, peat, wood, liquor, etc. are very rarely used. In addition to electricity, thermal power plants provide consumers with heat and hot water.

About 17-18% of electricity in Russia is generated by hydroelectric power plants. This represents over 99% of the country's renewable energy generation (as of 2018). Of these, about 19% of electricity is generated by nuclear energy (as of January 2019). For comparison, the following EU countries have the largest percentage of electricity generation using renewable energy sources: Sweden (about 58.7%), Portugal (55.0%), Germany and Romania (41.2% each). In such EU countries as Germany and Portugal, the share of solar and wind energy in RES is 28.9% [2].

In Russia, the share of renewable energy is extremely small. In 2018, the total electricity generation by RES-based power plants amounted to about 0.1% of all electricity generated. Renewable energy in Russia mainly includes solar, wind and geothermal energy. There are also several small power plants based on biogas and biofuel and an experimental Kislogubskaya tidal power plant [3].
Nevertheless, Russia has a unique natural potential for renewable energy sources. This country is a country with high insolation. The climate in most of the territory of the Russian Federation is continental and sharply continental with low clouds. In this case, the temperature coefficient of power even increases with decreasing temperature. Insolation in some regions of Russia is higher than in Europe.

The climate of Russia is also promising for wind energy. The regions isolated from the unified power system have the highest wind potential.

According to various estimates, about 70% of the territory of the Russian Federation with a population of more than 20 million people is located in areas of autonomous, expensive or unreliable centralized energy supply. Even such developed regions as, for example, the Krasnodar Territory, experience a capacity deficit of about 7 GWt and, as a result, face regular power outages, especially in the summer months. Together with the low cost of solar power plants, this will stimulate Russian businesses to switch to renewable energy sources in the coming years. [4].

Since in Russia, unlike in European countries, the introduction of renewable energy sources into the energy market is just beginning, the price-dependent consumption reduction mechanism of the wholesale market entities began to operate in 2017. In 2019, this mechanism was launched in a pilot mode, taking into account the identified shortcomings.

The Russian state is taking measures to support the development of renewable energy, such as the competitive selection of power plants based on RES. The selected projects are provided with a payback due to the increased capacity fees.

In the EU, the demand management policy was introduced long ago and has already received its positive results.

In August 2020, the Ministry of Economic Development of Russia sent for approval a new draft action plan to improve the energy efficiency of the economy. To develop ways to finance energy efficiency improvements, measures were proposed: removing restrictions on the development of energy service activities, attracting green investments in energy saving, concessional lending for energy efficiency projects, including for the population and small and medium-sized businesses. It was also proposed to create a specialized fund, the funds of which will be invested in energy efficient projects. The developed plan is aimed at improving the energy efficiency of the most energy-intensive areas of the economy, whose energy consumption in the country exceeds 80%. These are such areas as energy, industry, transport and housing and communal services. The implementation of the measures of the new comprehensive plan only due to the technological factor will reduce the energy intensity of GDP by 20% by 2030 compared to 2017. The total decrease in the energy intensity of GDP will be up to 35%. [5].

2. RES-powered charging stations for electric vehicles

One of the most promising and rapidly developing areas around the world is electric vehicles. This type of transport practically does not pollute the environment. Every year, electric cars are gradually beginning to be introduced into everyday life, thereby replacing “traditional” cars. According to Vygon Consulting forecasts, without special support measures, the fleet of private electric vehicles in Russia will exceed 150,000 units by 2025 (two out of a hundred new cars will be electric), while the taxi and car-sharing fleet in large cities will become electric by 25% (125,000 units). By 2025, 80,000 electric buses can operate in the country, which is about 20% of the total Russian fleet, but this will require targeted measures from cities with a population of over one million. In mid-March 2020, the Council of the Eurasian Economic Commission decided to zero customs duties on the import of electric vehicles for Russia and other countries of the European Economic Union [6].

The main problem that hinders the development and distribution of electric vehicles is the impossibility of charging them by residents of an apartment building, as well as long charging directly from a single-phase network with voltages of 220 V. In this work, fast and affordable charging is proposed. It is proposed to install charging stations for electric vehicles in parking lots near large shopping centers, manufacturing plants, etc. The driver will be able to recharge his electric car while shopping at the supermarket or while at work. The charging stations will be powered by photovoltaic
panels. The panels are supposed to be placed on top of parking lots. Since the charging stations will be powered by photovoltaic batteries, the problem of overloading the power grid, which can arise from the rapid charging of several electric vehicles, will be solved. Also, the problem of smoothing out the load peaks during rush hour can be solved, due to the sale of a part of the energy stored in the batteries.

It is assumed that such stations will have several connectors: for AC and DC power supply, i.e. they will be able to produce 2 charging sessions at the same time: one fast, the other slow. The charging station will have Combo-2, Chade MO, Type 1/2 connectors that will ensure compatibility with all electric vehicles. Output parameters (maximum output power, maximum output voltage, maximum output current, number of phases, equipment) in the operating mode of direct and alternating current will not differ from similar charging power plants produced by Russian and foreign companies. By using a three-phase converter, charging will be carried out in a shorter time.

The electricity generated by the photovoltaic panels will be stored in batteries. During periods when there are no charged electric vehicles, the photovoltaic station can generate electricity to smooth out the load peaks of the nearest transformer substation or sell it to the external network (figure 1). The control module is used to control power between the photovoltaic panel, battery, DC load, AC load and the grid. If the battery is fully charged, then in the absence of rechargeable electric vehicles, energy can be transferred to the external network or, if necessary, smooth out the load peaks of the nearest transformer substation.

![Figure 1. Block diagram of a RES-powered charging stations for electric vehicles.](image)

The cost of the proposed charging power plant will be approximately 30% higher than the cost of similar traditional charging power plants, due to additional costs for: control modules and photovoltaic panels, their installation in parking lots. An equally important positive effect is the absence of the need to increase the transmitted power to power the charging stations and the ability to smooth out load peaks.

In Russia, the development of an electric charging station powered by solar panels was carried out by students of the Peter the Great St. Petersburg Polytechnic University with the support of the MicroArt company, which produces inverters and controllers for solar panels [7]. They have reproduced their work in practice. The possibilities of smoothing the load peaks of the nearest transformer substation or selling electricity to the grid were not implemented in the above project. There are foreign studies on autonomous photovoltaic power supply systems. For example, in [8], it is proposed to use a hybrid energy storage system based on supercapacitors and lead-acid batteries as a storage device. In our work, we propose to use lithium-ion batteries as storage devices. They are distinguished by a large number of full discharge cycles, sufficiently high power, reliability, and a low self-discharge level. Their cost is steadily decreasing. In [9], only the load curve smoothing device and its operation algorithm are given.
All existing electric charging stations in Russia operate from a common network, they consume significant power, so the cost of charging will also include the cost of electricity consumed. The sale of accumulated electricity to the external network is currently performed in Russia only in pilot projects. Energy developed countries have long practiced balancing load peaks and selling electricity by renewable energy sources and storage devices. This is enshrined in legislation and is stimulated by various programs and tariffs. In Russia, the legislation regulating the issue of generating electricity from renewable energy sources in the grid or selling it is not fully developed, which makes it difficult to implement it.

Thus, the proposed smart charging station for electric vehicles will not have all the disadvantages that are inherent in traditional charging stations. They will not load the electric grid, they will be more economical and environmentally friendly. And the possibility with their help to smooth out load peaks or to sell the accumulated electricity to the network will give an additional economic effect. In the perspective of reducing the cost of solar panels, such charging stations in some regions of Russia can replace charging stations powered only from the electric network.

3. Conclusion
Currently, the Russian Federation has taken a course towards the development of renewable energy technologies and their implementation. The above analysis shows that it will not be possible to catch up with the energetically developed countries of Russia in this matter. However, the Russian government understands the need to develop and implement renewable energy technologies. Own production of wind turbines, solar panels, control modules, etc. is the main factor influencing the green energy prospects in the country.

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