Solution for renewable future

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Abstract. Nowadays renewable energy sources are actively promoted as the most sustainable types of power to drive electricity generation of the future. Distributed generation with the use of wind turbines, solar panel, and biological fuel may become an answer to the numerous challenges which large power grids are facing. But integration of renewable energy based generation facilities requires not only availability of special technical means but also establishing of new types of trading patterns and platforms are necessary. This article provides the concept of smart billing system which allows to involve single households to the progressive type of energy consumption and generation and creates the new type of energy system and market participant – prosumer. Two types of billing approaches are suggested for households equipped with renewable energy sources based generation facilities. The first one implies that generated energy is consumed by the household itself and the second one implies that surplus of generated energy is sold to the grid. As calculation has shown the first pattern is beneficial for small facilities which in overall don't have a large surplus in generation over consumption. And the second one is beneficial for those who generate more than they consume.

1 Modern challenges for the power system of Russia

One of the challenges of the energy security doctrine, approved by the Presidential decree 216 of May 13, 2019, is an increase in the share of renewable energy sources (RES) in the global fuel and energy balance. In order to form an adequate response to this challenge, Russia needs the development and support of domestic manufacturers of equipment for renewable sources, as well as mechanisms for supporting renewable energy and creating a convenient platform for mutual settlements of a new type of consumer / producer - prosumer and the traditional system for selling electricity [1, 2]. Such a shift will be possible due to the development of intelligent technologies in the field of energy and the steady increase in the amount of renewable energy, which are the objectives of the above-mentioned doctrine.

In addition to the policy of our state, aimed at supporting the development of renewable sources, an initiative of investment and venture funds is necessary [3]. A flexible tax policy of the state, as well as support for prosumers in the consumption and production of clean energy should be introduced [4]. Of great importance is the readiness of scientific organizations to develop competitive domestic equipment and local factories to begin production of equipment intended for the use of renewable energy sources.

2 Current level of development of renewable energy generation

According to the International Energy Agency (IEA) [5] the share of renewable energy sources is expected to grow by 20% and reach 12.4% of the total world consumption in 2023.

The growth rates of renewable energy in the world energy balance show a steady growth over the last ten years, so in 2018 the commissioning of capacities using renewable energy was 181 GW, in 2017 - by 8% less than in 2018, and a year earlier only 85 GW [6]. Currently, hydropower industry remains the largest renewable source based type of generation in the world, with a share of 16% of global electricity generation, wind power is in the second place accounting about 6% and solar photovoltaic energy is in third place (4%).

Nevertheless, the last three years, solar energy has led the growth of clean energy capacity, which is explained by scientific and technological progress in the development of materials used in the solar photovoltaic industry and, as a result, a decrease in the specific capital investments in solar panels, which continues for last decade [7-9].

In many developed countries, as well as places where centralized power supply is unavailable, for example, islands or, as is typical for Russia, a huge number of regions that have difficulties with access to power supply, in which RES will be competitive, it is necessary to pay attention to the development of distributed power supply to consumers [10, 11]. To meet this energy need,

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77% of global demand refers to buying a home solar system. Therefore, the use of distributed renewable energy, intellectualization of infrastructure and the transition of consumers to active, prosumer behavior patterns is obvious [12-16].

3 Smart billing system concept for prosumers

With this in mind, the solution to accelerate the integration of renewable energy sources into the power grid is the development and implementation of a system that supports mutual settlements with facilities operating renewable energy installations. Moreover, these objects do not necessarily should be of large capacities. These can be single households or communities. Every inhabitant of the planet may be involved in the system of progressive use of electricity through the introduction of a smart trading system. Technically, this system can be organized according to the scheme presented in Figure 1.

From various devices that consume or generate electricity at the facility, data is collected into a single intelligent system for calculating consumption. Then all the information is collected on the server of the energy trading organization that supports cloud storage. On this server, financial calculations for electricity are carried out. All information about its consumption and the state of its electricity bill is available to the user from the facility in a mobile application that communicates with the cloud data storage at any time of the day. The figure for example shows PLC technology and optic cables as options for communication lines between system components, but it is also possible to use twisted pair cabling or wireless data transmission.

From the point of view of financial calculations, the system can support two variants of calculations. Let's call them RES utility credit and RES utility billing. Their difference lies in the fact that the RES utility credit allows the prosumer to use the meter in both directions. But it is impossible to sell the generated electricity, as it can be used only for own consumption. RES utility billing implies the presence of two meters - one to

calculate consumption, the second to calculate generation. And the financial operations are carried out separately for each meter.

RES utility credit requires the use of one bi-directional meter. Consumer only buys electricity from the grid at retail price. RES utility billing is built with the use of two electricity meters. Facility buys electricity from the grid (or trading company) at retail price and sells generated energy at wholesale price.

4 Assessment of smart billing profitability

For the economic evaluation of the proposed computational models, we carried out a calculation of the expected generation received from solar panels installed on the roof of a residential building in the city of Kazan, and income from its use. We have calculated various options for the implementation of this generated energy. In the first version, the energy was consumed by a residential house, both from the grid and from its own solar panels. In the months when the generation of solar panels exceeded the demand for electricity in a residential building, the excess accumulated. In the second case, the excess energy generated by solar panels was sold to the power trading company.

The last column in the tables 1 and 2 shows the state of the user's account in the energy trading organization. The monthly amount on the account is determined based on the average household electricity consumption rate (the base tariff in Russia is 2.36 euros) and the amount of electricity sold or additionally consumed. Electricity consumption is charged at a price of 0.04 euro / kWh, electricity is sold at a price of 0.01 euro / kWh. In this case, the total year consumption is 7120,797 kWh, the total year generation is 6901,912 kWh.

At the same time, by the end of the year, the user's debt to the energy trading organization when using RES utility credit amounted to 67.0576 euros, and when using the RES utility billing is 103,0949 euros. Similar calculations for facilities with different ratios of generation and consumption showed that that RES utility

Fig. 1. Smart billing system scheme.

credit is beneficial for small facilities which in overall don't have a large surplus in generation over consumption. And RES utility billing is beneficial for those who generate more than they consume.

5 Recommendations for smart billing system implementation strategy

As a first step to the implementation of the proposed concept of an energy trading system, changes should be made in tax legislation that will be aimed at stimulating the development of renewable energy. Such measures, in relation to prosumers, can be reduced to zero value-added tax when transporting solar panels for prosumers, tax benefits for the purchase and installation of solar panels for prosumers, as well as the provision of tax holidays for the first years of using equipment that will stimulate demand for technologies based on renewable energy. Moreover, in order to support prosumers, it is necessary to reduce the property tax and introduce state subsidies for interest rates on loans for renewable energy

facilities.

As an indirect method of stimulating renewable energy, it is recommended to increase the tax rate on the use of fossil fuels and the introduction of a carbon tax, which will trigger to the development of renewable energy, the interest of private investors and the development of new technologies that are so necessary for Russia today.

The next step is to agree on the procedure for technological connection to the network object. Here the technological process of RES based generation should be supported by the grid facilities and grid operator. After that, the establishment of principles of contractual relations with the energy trading organization is carried out. That in general means the choice of billing model for the household. To implement this step the energy trading organization should be equipped with computer complexes and accounting system should be certified. The final step is the building of RES generation facility to be operated by the household and its subsequent operation and maintenance.

Today, the extent of integration of renewable energy

Table 1. Calculation for RES utility credit.

Month	RES generation, kWh	Total consumption, kWh	Consumption from the grid, kWh	Accumulation from RES, kWh	Account, Euro
January	100,335	581,742	-481,407	0	-2,36-0,04×481,407
February	268,457	644,071	-375,614	0	-2,36-0,04×375,614
March	470,323	581,742	-111,419	0	-2,36-0,04×111,419
April	788,4	601,133	187,267	187,267	-2,36
May	1051	581,742	469,258	656,525	-2,36
June	1283	601,133	681,867	1338,392	-2,36
July	1106	581,742	524,258	1862,65	-2,36
August	919,742	581,742	338	2200,65	-2,36
September	511,92	601,133	-89,213	0	-2,36
October	242,477	581,742	-339,265	0	-2,36
November	108	601,133	-493,133	0	-2,36
December	52,258	581,742	-529,484	0	-2,36
Total	6901,912	7120,797	-218,885	6245,484	-67,0576

Table 2. Calculation for RES utility billing.

Month	RES generation, kWh	Total consumption, kWh	Consumption from the grid, kWh	Account, Euro
January	100,335	581,742	-481,407	-2,36-0,04×481,407
February	268,457	644,071	-375,614	-2,36-0,04×375,614
March	470,323	581,742	-111,419	-2,36-0,04×111,419
April	788,4	601,133	187,267	-2,36+0,01×187,267
May	1051	581,742	469,258	-2,36+0,01×469,258
June	1283	601,133	681,867	-2,36+0,01×681,867
July	1106	581,742	524,258	-2,36+0,01×524,258
August	919,742	581,742	338	-2,36+0,01×338
September	511,92	601,133	-89,213	-2,36-0,04×89,213
October	242,477	581,742	-339,265	-2,36-0,04×339,265
November	108	601,133	-493,133	-2,36-0,04×493,133
December	52,258	581,742	-529,484	-2,36-0,04×529,484
Total	6901,912	7120,797	-218,885	-103,0949

sources in the energy system is an indicator of the technological and industrial development of the state. Renewable energy is the driver of economic, science and education development. In the context of the transformation of world energy systems with deep decentralization of electricity production, the use of energy-saving technologies, digital technologies and intelligent control systems, cloud technologies, blockchain and other new financial technologies as RES credit and billing will determine the future of power generation. For Russia, it is important to stay on the wave of overall development and transition to a new technological pattern in order to maintain competitiveness on the world stage.

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