Perspectives on Distributed Generation in the Electric Power Industry

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1 Introduction

Over the last 20–30 years, the electric power sector has tended towards policies favouring liberalization, diversification, decentralization, modernization, and integration. Since the beginning of the 1990s, many countries have introduced reforms into their electric power industries with respect to liberalization, privatization, integrating regional power markets, and attraction of private capital into competitive sectors (generation, etc.).

The development of distributed generation (DG) relies on a wide range of factors, and this very tendency creates new challenges and tasks for power supply systems in the fields of active demand management and implementation of "smart" equipment, advanced energy generation, storage technologies, etc. Development of renewable energy sources (RES), alternative generation technologies, smart energy systems, and distributed generation has increased since the year 2000; furthermore, since 2006, this trend had become one of the more noticeable tendencies in many countries [1–3].

Developing DG in the countries with irregular distribution of population and well-developed heat and electric power systems has some special problems. We consider the Russian power sector as an example. We analyse how DG is being developed in the Russian economy in comparison with worldwide tendencies, its special characteristics, challenges, and obstacles.

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2 Main Tendencies for the Development of Distributed Generation in the World

The International Energy Agency (IEA) identifies the following factors in the development of DG in the last decades [4]: development of DG technologies, deferral for upgrades of transmission systems, energy security (diversification of primary energy resources balance and growth in consumer demand for more reliable energy supply channels), environmental protection, and liberalization of the electric power markets.

The leaders in the development of DG are countries where energy policy stimulates this sector, including such directions as renewable energy source (RES), cogeneration, smart grid system implementation, and energy balance diversification (the USA, China, Denmark, Germany, Spain, Japan, etc.). Development of RES and the smart grid system is connected with technological modernization and are not merely the next step for the industry or solely a result of liberalization.

According to the estimation of Global Data, DG capacities will double over the next few years (from 190 GW in 2013 to 389 GW by 2019) [5]. RES generation has priority, specifically solar photovoltaic (PV) generation and wind generation. Also it concerns high-efficiency combined heat and power (CHP) generation. It should be noted that progress in DG development relies heavily on regulator activity, since usually the participants in the "large" electric power system (utilities, companies in generation, transmission sectors, system operator, etc.) do not function as the main drivers in promoting decentralization in the industry. Appearance of new (independent) power producers increases competition in the market and forces down a market share of incumbents, which the older players naturally resist.

The experience of the USA and other countries has shown that there are the following several types of barriers for DG development [1, 4]:

- *Technical*: different technical and juridical requirements (from system operator (SO), transmission/distribution operators (TO/DO)) in order to obtain technical connection to grid or approval for capacity installation. These requirements are too often excessive and sometimes based on obsolete technological decisions.
- *Business practice*: overstatement of price (for capacity reservation for DG or technical connection to grid) and emergence of obstacles for a deal and contract.
- *Regulation*: prohibition by local authorities of DG plant installation (on the grounds of environmental protection or supporting of the centralized electric power system), levying of inconvenient tariffs on RG, etc.

3 Distributed Generation in Russia

The Russian electricity power sector has been in the process of transformation and modernisation for the last 25 years. However this process has been coming to fruition more slowly than in other countries.

The special aspect of the Russian electricity power industry is the geography factor. The country has large and long-distance territory where economy and population are distributed irregularly. About two thirds of the country's territory is outside the centralized electricity power service mainly due to long distances and low density of population, and consequently in those regions, the electric power industry has generally developed in a decentralized manner, relying on small capacity generators generally.

Consequently, DG is present in the Russian electric power sector, though its share was small up until the last decade, when it began to grow, and one of the main trends is the development of consumer generation. The main drivers for this process are problems with reliability of electricity supply and limitation of access to the electric power infrastructure.

It is important to note that development of DG started in the first half of 2000s, and it was before the onset of high price growth in electricity and the completion of the reform of the electric power industry. In the period between 2002 and 2007, the capacity of small and distributed generation (under 50 GW) increased by 25% (2.3 GW) and import increased 12-fold [6]. According to expert estimation in the period from 2012 to 2014, the annual import of equipment for DG (under 25 MW) in Russia was 1.5–2.5 GW. Total expenditure for the import of equipment for DG is more than USD 3 billion [7].

Specificity of Russia DG is developing by consumers of cogeneration on fossil fuels with a capacity of 0.1–25 MW. It can be explained by the cold climate, inappropriate conditions of centralized heat systems in many towns, and the availability of gas supply in the European part of the country. Also, a number of industrial plants produce waste products, which can be used as fuel for electricity or heat generation.

There are no official statistics about DG by consumers. According to expert estimation, DG by consumers grows more rapidly in the industrially developed regions of the South Ural, where industrial plants actively install DG capacities [8]. Additionally, in any cases where consumers switched to "islanding" (isolated operation).

DG is in demand by a wide range of economic agents in the Russian economy from a small to large volume of electricity consumption. First of all, DG is needed in heating systems, in energy-intensive industries (chemical, petrochemical, pulp and paper, iron and steel mills), in transport, and in telecommunications and also by consumers in the isolated and remote territories off the central supply grid.

The advantage of implementing DG in Russia as well as worldwide is its short construction period of 1–2 years, in contrast with the 3–6 years or more required for larger capacity plants. The costs involved in DG projects vary greatly based on a range of factors. Experts' estimates in 2012, evaluated the electricity power price threshold for turning a profit on DG installation projects at about 2.5–3.0 roubles/kW. If the electricity prices, as set by electric power industry, as high, then it is profitable to install own DG plant and expected payback in less than 10 years' time. If consumers install cogeneration capacity and equally utilize both electricity and heat produced, then it is profitable to do so under any market conditions, and the payback period will be 2–5 years.

Therefore, there is no basis to the claim that DG development is just a consumer response to unsuccessful reforms in the electric power industry. The development of DG is a common worldwide tendency, and it started in the Russian economy (as in the USA, EC, other countries and regions) when (1) the electricity power system demonstrated its unreliability or technical limitations and (2) it became possible to realize a commercial project in RG (including projects by consumers). Additionally fast electricity price growth and numerous problems with grid connection have forced consumers to develop DG in the last few years.

Thus, the main causes for the development of DG in Russia are as follows:

- Progress in science and technology and appearance of effective generation (and cogeneration) technologies for small-scale capacities
- Demand for reliability enhancement on local levels (installation of reserve, emergency, and prime capacities)
- High electricity prices for industrial consumers (the main reason for consumer price growth being the rapid increase in tariffs on transmission, rather than wholesale market price growth)
- Obligation for consumers to take part in the capacity market and to be charged additionally (include fees for "must-run" generation capacity)
- Optimization of consumers' energy expenses (electricity and heat)
- Adoption of local energy resources (including RES and waste products)
- Difficulty and duration of procedures for grid connection
- Provision of energy supply in isolated and remote territories
- Uncertainty in the mechanisms of electric power industry regulation and lack of clear development strategy for the current model of the electric power industry (both reasons issue risks for consumers and private investors)

A value of DG (under 25 MW) in the Russian economy can be estimated as 7–15 GW, and its share in total electricity production is 5–8% approximately. Current indirect expert estimates vary greatly from one another, and meanwhile a significant part of micro generation (especially that which produces under 500 kW) remains excluded from official statistics. The potential for development of DG in Russia is substantial, but estimates are quite approximate. According to the evaluation of the Agency for Forecasting of Electric Energy Balance (AFEB), it takes 50 GW of small and medium (under 100 MW) cogeneration capacities for heat system modernization. The potential for RG development in the Russian industry sector is at least 15 GW [9]. Furthermore, there are significant possibilities for DG development in other sectors of the economy (transport, householders, consumer services, etc.). Some experts evaluate the total potential for DG development in the Russian economy to reach 65–90 GW by 2030 [10].

The development of RES generation has become a worldwide trend in the last 7–8 years, but this trend has not been significantly detected in the Russian economy. Neither regulators, nor companies in the generation sector of electric power industry, have expressed significant interest in renewable (and new alternative) energy due to extensive deposits of fossil resources available in the country. Participants in the Russian UES have no incentives for development of new type of prime energy

resources, and their reluctance comes across in documents outlining strategies for the industry itself as well as for the fuel and energy sector of the economy as a whole.

Accordingly, these strategies' development of RES in the Russian economy will necessarily occur at a slow rate. Despite this regulators do implement some incentives for RES development in the market zone of unified energy system (UES) such as solar PV and wind plants and small hydrogenation power plants (guarantee of costs recovery for the auction winners by capacity payment mechanism), but participants in the wholesale electricity market, including both producers and consumers, oppose this initiative, since new renewable generation capacities would not only compete with options provided by other electricity power producers but also lay an additional financial burden on consumers.

This conflict of interest is further exacerbated by the current condition of a capacity reserve in the electricity power system surplus. Also it should be taken into account that the GDP growth has dropped dramatically in the last few years. As the situation stands, consumer development of RES projects is mainly limited to enthusiasts operating without any support from regulators. Nevertheless, there remains a stable consumer interest in the development of DG in the following spheres of activity:

- In isolated and remote territories due to high costs of electricity production. A main part of generation in isolated and long-distance territories is thermal power plants, and they use fossil (diesel or coal) fuel. Cost of electricity production is about 15–100 roubles/kWh. In these regions it could be profitable to install hybrid power plants (solar PV and diesel generator, solar PV and wind generator, geothermal plants, etc.).
- In the regions where locally there is fuel RES (biogas, wood waste, etc.).

According to non-profit partnership "Market Council" [11] estimates, the potential for RES generation development in the Russian electricity power industry because of government support and incentives exceeds 25 GW. At the same time according to experts' evaluation, Russia has the resources to develop all types of RES generation and is hypothetically able to meet all its electrical supply in full on the basis of domestic RES resources alone.

In many cases (but not all), development of cogeneration and usage of local prime energy resources for decentralized energy supply by means of DG (including both electric power and heat production) are more effective than installation of large-scale centralized systems (including a generation sector and long-distance transmission networks).

Furthermore, development of DG is beneficial for the country's energy security due to resultant diversification of the prime energy resources balance, and it is beneficial for improving of energy security of a country. It is well known, and many experts have written about these topics, but RG development has been out of strategy documents for industry. It should be noted that according to the Russian Energy Strategy 2030 the share of RG may increase by 15% of total production of electricity and heat.

Spontaneous development of individual generation capacities by consumers introduces additional uncertainty and extends the recovery period for investment projects in the Unified Energy System (UES) and local heat systems. This, in turn, can lead to negative consequences and additional price growth for the consumers who remain tied to these centralized energy systems.

4 Barriers to the Development of Distributed Generation in Russia

Participants of the electric power industry in Russia refer to development of RG mixed (as it is in some other countries), and they are not interested as a whole ring. The industry regulators and NP Market Council do implement measures (with some exception from the rule) to retain large consumers on the wholesale market. If consumers own generation capacity over 25 MW, they are obliged to sell all produced electricity on the wholesale market.

However, as previously discussed, there are barriers and excessive requirements of regulators for grid connection. Their following barriers have risen in the way of DG development in Russia, largely in connection with cooperation with the UES:

- Uncertain rules and barriers inhibiting connection to the UES grid. It is necessary to formalize and standardize regulatory procedures.
- Significant loopholes in regulation and legal framework with respect to DG (among other things – about retail electricity trade) and instability of legislation for the electric power industry.
- Development of technical standards in the UES without attention to DG and the absence of incentive for support of DG development (excluding measures for RES in UES).
- Duration of approval and agreement procedures in regulation bodies and insufficient information support for economic agents (the majority of them are not familiar with possibilities of DG).
- Uncertainty of forecasts for electricity (UES) and fuels prices.

It should be noted that there are not only possibilities but also objective difficulties in developing of DG in the Russian economy and integrating it into the UES; these difficulties are primarily technical.

Additionally, the deterioration of macroeconomic conditions will have a somewhat negative effect on the development of DG on midterm perspective: economic recession, depreciation and high volatility of exchange rates, high inflation rates, and growth of strategic uncertainty in the country development are all likely to adversely contribute to the situation.

5 Supporting Measures for the Development of DG in Russia

Though over the course of the last year the government and regulators have implemented certain measures for supporting DG, this activity has tapered off. In 2011–2012, the government established 32 technological platforms (TPs) to stimulate innovation in the development of the Russian economy. Five of these initiatives concern the electric power industry ("smart grid for Russia", "complex security of industry and energy sector", "environmentally clean effective thermal energy", "perspective technologies of renewable energy", "small-scale distributed energy").

Some proposals for supporting DG were developed and recommended by experts [9, 12]:

- Establishing priorities for installation and sale of electric power and heat for new cogeneration capacities on the market
- Setting a regulatory ban for installation or reconstruction of boiler stations without considering alternative options involving DG
- Simplifying the requirements for technical connection to grid
- Removing retraction to take part in the wholesale market for consumers' generation capacities above 25 MW
- Establishing a stable of legal and regulatory framework
- Developing generic solutions and technical standards for gas-consuming plants in cooperation with gas supply companies

These proposals address the complex set of problems that currently beset the electric power and heat industries. However there are not enough provisions for developing mechanisms for DG in both industries. It is also unclear how and when the logistic developments of municipal power and heat supply schemes will be synchronized, even though legislation has already started to address this issue. Overall, the proposed measures are nevertheless traditional, and they address the development of DG on grounds dictated by the UES rather than encompassing the interests of consumer-generated energy production.

6 Conclusion

Development of DG is one of the visible trends in the electric power industry worldwide. Governments and regulators in many countries facilitate the growth of DG by supporting RES, cogeneration, smart grid systems, "green energy", and increasing competition in the electricity power markets.

The specific case of DG development in Russia hinges on the slow, virtually insignificant integration rate of DG systems into the UES. Consumers install DG actively, but regulators do not support them. Moreover, there are numerous barriers and obstacles to consumers' development of DG. All official measures for

promoting DG (including RES) focus on the development of it into the UES and favour generation companies rather than consumers. Despite this, on the whole, the potential for developing DG in Russia is significant. But energy companies, which participate in the UES, along with regulators and the government, currently express little interest in promoting DG in the Russian energy sector. Synchronizing the development of the electric power and heat industries' development with the perspective on DG development by consumers (especially in the industry sector of the economy) constitutes a crucial step on the way to developing DG in Russia.

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