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SOME PROBLEMS OF ENERGY SECURITY IN THE CONTEXT OF WIDESPREAD USE OF RES

N. A. Yusifbayli[1]*, V. X. Nasibov[2]

[1]*Azerbaijan Technical University, Baku, Azerbaijan*

[2]*Azerbaijan Research and Design–Prospecting Institute of Energetics, Baku, Azerbaijan*

ABSTRACT

The potential use of renewable energy sources in Azerbaijan in the context of feasibility is reviewed in this paper. It is shown that in connection with the environmental problems associated with fuel combustion, as well as in connection with the depletion of fossil fuel reserves, it is advisable to use environmentally friendly and inexhaustible types of renewable energy sources.

KEYWORDS

Renewable energy sources;
İnstalled capacity;
Solar energy;
Wind energy;
Power plant;
Power generation.

1. Introduction

One of the most important problems of the modern world is the problem of climate change. The warming of the climate observed in recent decades is associated with the increasing concentration of six main greenhouse gases in the atmosphere, and first of all, CO_2. 40% of their emission occurs during the combustion of fossil fuel.

The Kyoto Protocol, adopted in 1997, was the first document in accordance with which governments assumed legal obligations to limit greenhouse gas emissions.

Following of the Kyoto Protocol, the Paris Climate Conference the Paris Agreement was adopted in 2015. Then latter one is aimed to «intensify implementation» of the UN Framework Convention on Climate Change, in particular, to restrain the growth in global average temperature and make efforts for the limitation of the temperature rise to 1.5 °C.

Above mentioned the Kyoto Protocol and the Paris Agreement did not bring tangible changes towards stabilization of the Earth's climate. In September 2021, the UN Climate Conference COP26 was held in Glasgow with the participation of more than 100 heads of states and governments. The purpose of this conference was to join efforts of countries in the fight against further climate change on the planet. To stop climate change, it is necessary to reduce the consumption of carbon-rich fossil fuel using renewable energy sources (RES).

The declining costs of the capex and opex of renewable energy generation, which opens up vast opportunities for the reconstruction of the electricity sector, play an important role in ensuring the energy security of the energy produced by these technologies [1,2]. Wind and solar photovoltaic (PV) plants will provide more than half of the additional electricity generation by 2040 and almost all of the growth in terms of fulfilling the UN climate change commitments under the UN Convention on Climate Change (TC 21, Paris Agreement). Governments and regulators will have to act quickly to keep up with the pace of technological change and the growing need for flexible operation of energy systems. The rapid development of the market of energy storage technologies, the interface between electric vehicles and the network, the confidentiality of data, etc. issues are becoming a potential source of risk for consumers and national power systems [3,4].

2. Use of RES in the world

Sustainable development and use of RES is observed in many countries of the world. In 2020 the 27 EU countries, for the first time, generate the essential part of electricity from renewable energy sources. The share of coal, gas and oil fell to 37%, while wind, solar, hydropower and biomass increased production by 10%, accounting for 38% of total generation in EU. According to the forecasts of the European Association for Renewable Energy Sources, by 2040 about 50% of the world's electricity generation will be based on RES.

According to the International Renewable Energy Agency (IRENA), the installed capacity of renewable energy sources globally in 2020 was 2799094 MW, thus the share of RES in the total installed capacity was 36.6% (fig. 1) [5].

Despite the economic downturn due to COVID-19, the annual growth of renewable energy in 2020 was 260 GWh, which is 50% more than in 2019. By 2030, the share of renewable energy sources in the EU energy balance will increase from 32% to 60%. Figure 2 shows the dynamics of the growth of renewable energy sources in the world - in 2020 the annual growth was 10.3%.

Despite the economic crisis, with the 9% and 15% growth of wind and solar energy respectively in 2020, RES have become the leaders in power generation.

Last year, renewable energy provided 19% of the

**E-mail:* yusifbayli.n@gmail.com

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Fig. 1. Installed capacity of RES according to IRENA

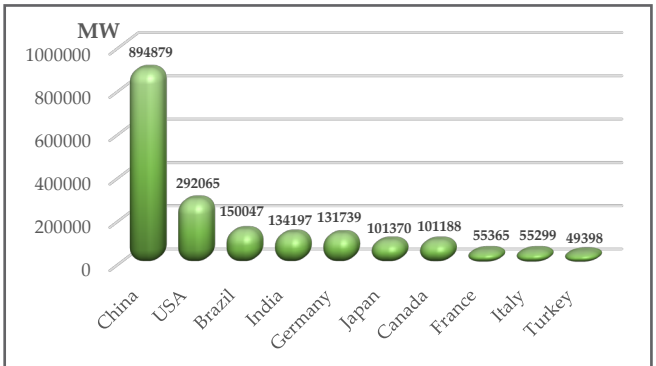

Fig. 2. Dynamics of RES growth in the world for 2020

electrification of the EU (almost a fifth): the share of wind energy was 14%, and the share of solar - 5% [6-9].

The leaders in the production of wind and solar energy in the EU are shown in figure 3.

As is obvious from the figure, in 2020 the largest share of solar and wind energy in electric power was obtained in Germany (50%), Denmark (48%), Ireland (38%) and Spain (37%).

3. Current state and forecasts of RES in Azerbaijan

The total capacity of electricity generated in Azerbaijan is 7516 MW, of which 1278 MW is the capacity of power plants using renewable energy sources, including large hydroelectric power plants, which is 17% of the total capacity. At that, the hydropower plant capacity is 1135 MW (22 plants, 12 small HPPs), wind energy is 66 MW (5 plants, 1 hybrid), bioenergy capacity is 38 MW (2 plants, 1 hybrid), solar energy capacity is 40 MW (9 plants, 1 hybrid).

In 2020 the electricity generation in the country amounted to 25.8 TWh, of which 24.3 TWh fall on thermal power plants and 1,069.5 GWh fall on hydropower plants. The electric power generation at wind and solar power plants and at solid waste incineration plant amounted to 343.55 GWh. During the year, 96.1 GWh of electric power was produced at wind farms, 46.9 GWh at solar power plants and 200.6 GWh at solid waste incineration plant. Thus, the electric power produced from renewable energy sources accounted for about 6% of the total production.

Azerbaijan is one of the world's oldest oil and gas producing countries (with proven oil reserves of more than 1 billion tons by 2019, as well as about 2.1 trillion cubic meters of natural gas reserves, as well as great potential for renewable energy development [10-12].

The country has high wind and solar resources and significant prospects in terms of biomass, geothermal and

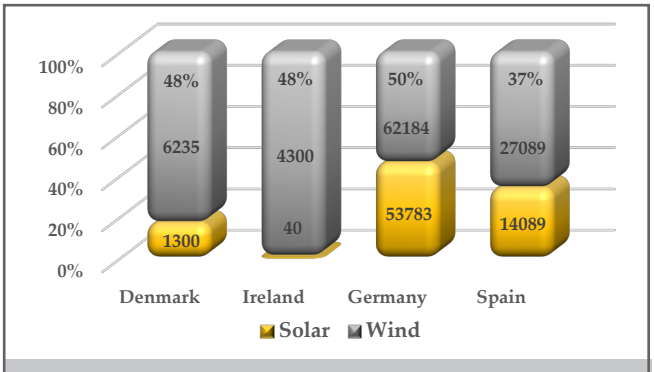

Fig. 3. Leaders in the production of wind and solar energy in the EU

hydropower plants > 500 MW for hydropower, solar FV > 23000 MW, wind (onshore) > 3000 MW, waste/bioenergy is 380 MW, with a total of > 27,000 MW. In addition, the potential for additional renewable heat (biomass, solar thermal, geothermal) for independent systems in remote rural areas is estimated at approximately 0.6 MNET/year. In order to realize this potential, the Government adopted a Strategic Roadmap in 2016. The Roadmap had set a goal to increase its renewable energy source by 420 MW by 2020. In reference to this goal, several contracts have been signed for the construction of RES (Khizi and Pirakushkul WPP, with an installed capacity of 240 MW, Alat PVPP, 230 MW) and in the Karabakh region with a capacity of more than 300 MW. Preliminary feasibility studies for the construction of the PVPP are being implemented. At the same time, the introduction of the «net metering» rule in the calculation of electricity will lead to the emergence of small strong VRES-based active consumers in individual homes over the next 5 years. It is estimated that the total capacity of such sources may exceed 1.000 MW. In other words, the total volume of VRES in the next five years can be projected at more than 2.000 MW, which allows us to predict that the share of EES in installed capacity will be more than 25%.

Renewable energy sources also offer a sufficiently low-carbon solution to achieve Azerbaijan's goals under the United Nations Framework Convention on Climate Change. The country has undertaken commitment to reach 35% reduction in green hose emissions by 2030 compared to the base year of 1990, adopted in its National Contributed Document (NDC) under the Paris Agreement, and the use of RES is particularly important to achieve this goal.

«Green growth» occupies one of the central places in the National Priorities of Azerbaijan 2030: socio-economic development of the Republic of Azerbaijan. At the same time, green development is of particular importance in the implementation of the commitments of the United Nations, of which Azerbaijan is a partner, «Transformation of our world: Agenda for Sustainable Development until 2030.»

Various renewable energy sources have significantly increased the importance of flexibility and energy security in power systems (PS) against the backdrop of the widespread use of renewable energy sources. At the same time, new threats, from cybersecurity to rapidly changing weather conditions, require steady attention from governments. According to estimates, almost 1/5 of the increase in global energy consumption in 2018 was due to changes in weather conditions, i.e. cooling on hot summer days, and additional heating needs in cold weather. On July 21, 2021, due to the

high temperature in the Azerbaijan territory, the demand for maximum power and the production of daily electricity increased by an average of 12% [13-16].

At present, the share of energy sources in the capacity of Azerbaijan's thermal power plants is about 84% of conventional sources and RES of 16% (fig. 1). 14%). HPPs have a major share (90%) in the structure of RES. On average, 90% of renewable energy generation capacity is regulated RES-class hydropower plants (fig. 4, 5).

Azerbaijan is one of the countries rich in renewable energy sources. The government's goal is to increase the share of renewable energy sources in electricity generation to 30% by 2030, in order to ensure the efficient use of the potential of solar and wind energy. In this regard, by 2030 it is planned to commission about 1500 MW of new capacity. It is planned to do this through private investment (table).

Table

2020-2022	2023-2025	2026-2030
470 MW	460 MW	570 MW

4. Problems of integration of RES in power system

The increase in the share of generation based on wind and solar in the structure of the electric power industry in many countries and regions poses certain challenges for energy managers. How can an increasing proportion of unstable energy flows be safely integrated into the grid with the least energy loss and without compromising system reliability?

To date, a large amount of empirical data has been accumulated regarding the management of the network economy in the context of a high share and even dominance of renewable energy sources. Moreover, there is no shortage of theoretical studies and models of systems based on renewable energy sources.

The integration of small volumes of changeable RES into the grid is not a problem. Small volumes here mean a share of 5-10%.

In this case, you still need to follow some rules:

• Avoid uncontrolled local concentrations of RES («hot spots»);

• Ensure that RES power plants can «help» stabilize the grid when needed;

• Forecast electricity production from renewable energy sources and use these forecasts to plan the operation of other power plants and electricity flows in the grid.

Research in the regions of the project showed that the current level of flexibility of power systems technically allows «operation» with an annual share of variable generation of 25-40%. According to the same analysis, «in very flexible systems» the share of RES can exceed 50% levels if the possibility of forced shutdowns of «small volumes» of generation based on renewable sources is allowed.

The integration of large volumes of renewable energy sources requires the transformation of the energy system as a whole. In other words, we are not talking about a simple addition of new generation objects to the «old» system that works as usual, but about a complete reformatting of the system.

The costs associated with this transformation depend on different circumstances. Obviously, if a high share of renewable energy sources is added at a time (which, in general, does not happen), then system costs increase significantly. On the other hand, with a gradual development (taking into account a decrease in the cost of renewable energy technologies and, on the contrary, an increase in environmental charges in the future), zero or even negative growth of system costs is possible.

Increase in volumes of energy use from renewable sources not only reduces the volume of emission of carbon dioxide and other gases into the atmosphere, but also has several other advantages:

• RES are practically inexhaustible sources of energy, which helps in reducing dependence on depletable traditional energy sources such as oil, natural gas, coal, etc.

• They are domestic sources of energy and contribute to strengthening energy independence and security of energy supply at the national level.

• They are geographically dispersed, which leads to decentralization of power system, which lowers the load on infrastructure systems and reduces losses from energy transmission.

• They usually have low running costs, which are not affected by fluctuations in international markets and especially the prices of conventional fuels (crude oil, natural gas, coal).

• RES plants have relatively shorter commissioning time.

• RES installations are usually designed to the satisfaction of specific energy users / consumers, in both large and small scale, and have a relatively short start-up (mobilization) time, which allows a quick response to energy supply in accordance with energy needs.

• Investments in RES create a significant number of new jobs, especially at the local level.

Along with the advantages, RES also have a number of disadvantages:

• Fossil fuel still generate large amount of electric power. Actually, this means that one cannot rely exclusively on RES.

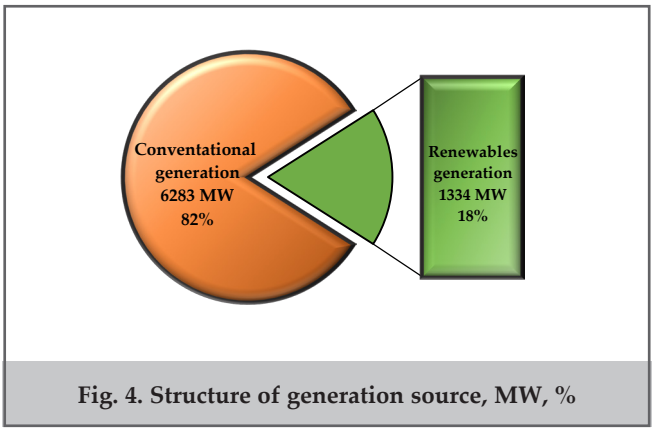

Fig. 4. Structure of generation source, MW, %

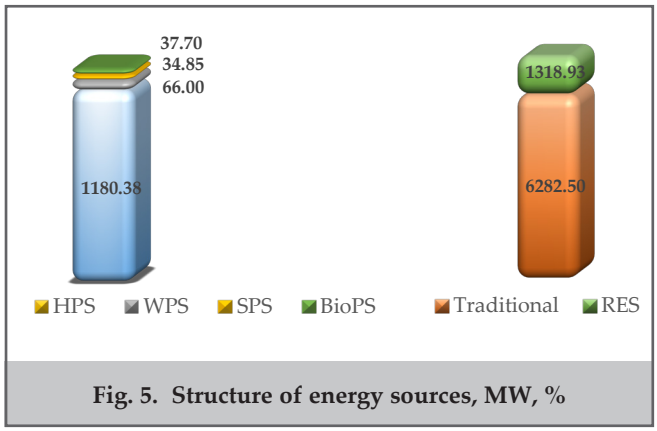

Fig. 5. Structure of energy sources, MW, %

• Renewable energy source technologies are completely dependent on the weather. In case atmospheric conditions are not good enough, renewable energy source technologies will not be able to produce electricity.

• The creation of renewable energy production capacities requires huge financial costs. For the construction of plants, the preliminary investment, high maintenance costs and careful planning and implementation are required. In addition, the generated electric power must be delivered to the cities, which means additional costs for the installation of power lines.

• A lot of space is required for RES plants.

• High storage costs [13-15].

4.1. The technical impact of the use of RES on the power generation system

The technical impact of RES on the generation system is inevitable.

One of the important features of RES (especially solar and wind) is that they have daily and seasonal fluctuations. This variable form of energy partially allows for performing a dispatching control.

Another impact of the widespread use of RES on the generation system is its (RES) excess production at minimum electric power demand. In this case, it becomes necessary to reduce the capacity of the base power plants to a minimum (in the power system of Azerbaijan, this is mainly the Azerbaijan TPP). The dispatcher must be able to control the variable nature of generation to ensure the stability of the power system operation mode.

When there is a lot of RES energy and there is no need for it, the energy storage mode (for example, through a pumped storage power plant, battery, etc.) increases the efficiency of RES energy use, but in this case, the energy storage requires large investments [16-18].

4.2. The technical impact of the use of RES on the electricity transmission and distribution system

The widespread use of distributed generation (including RES) during operation leads to an increase in uncertainty, which must be considered by the dispatcher (system operator) when making operational decisions. The power system must be able to quickly and efficiently reduce generation at decrease in demand and have an operational power reserve.

The dispatcher must respond to sudden changes in power flows, changes in flows may limit the transmission of electricity, and in some cases may cause a failure (emergency). Sharply variable generation powers can also adversely affect electric power quality, which can manifest as harmonics and twinkling.

The negative impact of RES is observed in these issues, including the sustainability of power system, the maintenance of reactive power and the provision of inertia, as well as the safety of power system.

According to the generally accepted rule, the reserve power in the power system is accepted equal to the power of the largest generation unit or the power lost due to the opening of line transmitting the electric power. Significant changes in RES-based generation can tighten requirements for both reserve power volume and power start-up rate. There may be a need to create new types of reserve power types and its activation system.

In addition, for example, the operation of wind farm can affect the quality of electric power and cause the formation of harmonics at junctions and overvoltage due to the electromagnetic transition process. A sharp loss of RES-based generation can lead to the following for the power system: exceeding the operating limits for power lines and equipment, as well as exceeding the stability limits of the power system; decrease of voltage resistance and control characteristics, reduction of dynamic stability and frequency adjustment characteristics of EES [13].

4.3. Possible problems during the operation of RES

Replacement of traditional generation with increasing RES leads to the decrease in possible operational options during operation and new problems:

• the problem of maintaining the required level of voltage, RES usually do not participate in the dynamic regulation of reactive power / voltage;

• the problem of keeping the short-circuit current at the required level to ensure the selective operation of the relay protection, rectifiers that connect the RES to the network usually do not perform this function;

• the problem of overload prevention, small energy facilities usually are not controlled (for example, solar plants in low-voltage systems);

• the problem of overloading control of networks due to the priority of transmission of electric power generated by RES.

Conclusion

Based on above analysis and discussions, the authors have come up with the following conclusion:

1. The growing development of RES in the world is an effective tool for preventing climate change.

2. Azerbaijan has extensive opportunities to use solar and wind energy.

3. Extensive use of RES in Azerbaijan will have positive effects such as reduced CO_2 emissions and gas fuel savings.

4. The widespread use of RES has the potential to have a significant impact on the generation system, transmission and distribution system. Replacement of traditional generation with increasing RES leads to new problems such as reduction of possible operational options during operation and violation of the selective operation of relay protection of short-circuit current, failure to ensure the required level of equivalent inertia constant.

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Некоторые проблемы энергетической безопасности в условиях широкого использования ВИЭ

Н.А. Юсифбейли[1], В.Х. Насибов[2]
[1]Азербайджанский Технический университет, Баку, Азербайджан
[2]Азербайджанский научно-исследовательский и проектно-изыскательский институт энергетики, Баку, Азербайджан

Реферат

В статье рассматривается использование (возможность использования) возобновляемых источников энергии в Азербайджане. Показано, что в связи с экологическими проблемами, связанными со сжиганием топлива, а также в связи с истощением запасов органического топлива целесообразно использовать экологически чистые и неисчерпаемые виды возобновляемых источников энергии.

Ключевые слова: возобновляемые источники энергии; установленная мощность; солнечная энергия; энергия ветра; электростанция; производство электроэнергии.

BEM-nin geniş istifadəsi zamanı enerji təhlükəsizliyinin bəzi problemləri

N.A. Yusifbəyli[1], V.X. Nəsibov[2]
[1]Azərbaycan Texniki Universiteti, Bakı, Azərbaycan
[2]Azərbaycan Elmi-Tədqiqat və Layihə-Axtarış Energetika İnstitutu, Bakı, Azərbaycan

Xülasə

Məqalədə Azərbaycanda bərpa olunan enerji mənbələrindən istifadə (istifadə imkanlarından) bəhs edilir. Göstərilir ki, yanacağın yanması ilə bağlı ekoloji problemlər, eləcə də yanacaq ehtiyatlarının tükənməsi ilə əlaqədar olaraq, ekoloji cəhətdən təmiz və tükənməz növ bərpa olunan enerji mənbələrindən istifadə etmək məqsədəuyğundur.

Açar sözlər: bərpa olunan enerji mənbələri; qoyuluş güc; günəş enerjisi; külək enerjisi; elektrik stansiyası; elektrik enerjisinin istehsalı.