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**Article**

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# New Energy System in the Republic of Kazakhstan: Exploring the Possibility of Creating and Mechanisms of Implementing

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**ABSTRACT**

The paper represents the analysis of modern data and information on the development of renewable energy sources (RES) and energy efficiency in the Republic of Kazakhstan. The purpose of this study is to identify trends in the development of alternative energy sources that are economically feasible at the current stage of the development of the energy complex and allow providing sustained growth in the national economy of the Republic of Kazakhstan. Analytical publications, interviews with experts, and other open sources of information were used as sources of secondary data. The conducted research allows formulating a number of conclusions. The Republic of Kazakhstan has a significant potential for the development of alternative energy. However, their share in total energy production remains rather low and the available capacities of the RES facilities are not fully utilized. In the context of aggravation of global environmental problems, depletion of traditional types of energy and raw material resources, it has proved necessary to create a new energy system based on RES. The Government of the Republic of Kazakhstan needs to develop a long-term concept of rendering sustainable energy services. In addition, it is necessary to implement a set of measures to strengthen the enabling environment, including higher investments into renewable facilities. One of the most promising mechanisms for supporting the RES sector is the introduction of an auction system for selecting RES projects, which will help solve problems with planning and control of the budget to support RES.

**Keywords:** Energy Efficiency, Energy Saving, Gross Domestic Product Energy Intensity, Renewable Energy Sources (RES), Alternative Energy, Solar Energy, Wind Power, Biofuels
**JEL Classifications:** O13, Q42, Q43.

## 1. INTRODUCTION

The high level of energy intensity of the economy of the Republic of Kazakhstan negatively affects the cost and competitiveness of products and the economy of the country as a whole. Improving energy efficiency is one of the priority tasks in the transition to a sustainable model of Kazakhstan's economic development.

In the Republic of Kazakhstan, several programs have been adopted to increase the share of renewable energy sources (RES) in electricity generation. The Government of the country has chosen energy saving and energy efficiency as the main priorities of the national energy policy, despite the fact that the country has significant energy resources and a developed energy infrastructure (Nazarbayev, 2011). In 2013, the concept of the transition to a "green economy" by 2050 was adopted, which means according to the document that half of the generated energy will be produced by RES. According to calculations in this concept, by 2050, transformations within the framework of the "green economy" will make it possible to further increase gross domestic product (GDP) by 3%, create more than 500 thousand new jobs, form new industries and services, and ensure high quality of life standards for the population everywhere. Investments in renewables are estimated at about 1% of GDP per year annually, but emissions reduction strategy will lead to additional savings, about 3-4 billion dollars per year.

The concept was formalized by the strategic development plan until 2020. In accordance with this document, the share of RES in the total electricity production by 2020 should be increased to 3%, and by 2030 the share of renewable energy should be equal to 30%. The Government set a goal to reduce GDP energy intensity by at least 40% by 2020 (Decree of the President of the Republic of Kazakhstan No. 577, 2013).

According to the Government of the Republic of Kazakhstan, the policy of efficient and balanced energy consumption restrains consumption growth and substantially reduces the environmental impact. Any efforts in this area will contribute to the modernization of the production sector, electric power industry, housing and utilities sector, and transport sector by encouraging the implementation of new technology and innovations (Energy Charter Secretariat, 2014).

In November 2011, Kazakhstan submitted a proposal to include in the agenda of the United Nations Conference on Sustainable Development a discussion of the global energy-ecological strategy for sustainable development in the 21st century. The ultimate goal of this strategy is to achieve, by the middle of the 21st century, an optimal level of meeting the needs of all countries in energy and other natural resources through the integrated improvement of the use of RES.

However, despite a number of legislative initiatives and measures of the general policy of increasing the energy efficiency of the Republic of Kazakhstan, it needs further improvement in accordance with the best international practice.

Despite the relatively high stock of traditional fuels, the creation of a new energy system based on RES is of particular importance. Kazakhstan owing to its natural resources has enormous potential for the introduction of RES, whether it is solar power plants (SPP), hydroelectric power plants (HPP) or wind power plants (WPP) (Kazakhstan Electricity Grid Operating Company KEGOC, 2013).

The Republic of Kazakhstan has a significant potential for the development of alternative energy. So, the potential of wind energy is estimated at 760-920 GWh per year, which is 10 times higher than the current electricity consumption in the country. Northern Kazakhstan, where winds reach 7.5 m/s, is a promising area, as well as other ideal characteristics for the Aeolian Park, such as the Shelek Gorge, which is in 100 km from Almaty, Zhambyl district in East Kazakhstan Region, Mangystau Mountains in Western Kazakhstan, etc.

The hydro potential of Kazakhstan is estimated at 62 billion kW, which is 70% of the total consumption in the country. As for the potential of solar energy in the southern regions of the country, it is about 2500-3000 thousand hours of sunshine per year, which corresponds to a capacity of 1200-1770 kW/m$^2$ per year, and allows the southern regions of Kazakhstan to be competitive with the sunniest countries in the world. This is approximately 2.5 billion KW per year. The construction of a plant for solar panels production in Astana will also contribute to the development of solar energy.

Experts identify two main reasons for the accelerated development of RES in the Republic of Kazakhstan. Firstly, there is an urgent need to reduce the emission of greenhouse gases and other pollutants, a major producer of which is fuel-energy complex of Kazakhstan, which burns mostly fossil fuel, namely coal, oil, and gas. Secondly, consumption of non-RES will increase, which will lead to a reduction in their reserves and may become a limiting factor for further economic growth. So, according to the forecast, consumption of primary energy resources by 2035 will increase by 4010 million tons in comparison with 2015 and will reach 17,157 million tons (BP Energy Outlook. 2017). The consumption of oil will increase by 15%, gas-by 38%, and coal-by 5%.

The relevance of developing alternative energy based on RES is caused by extremely high infrastructure wear and tear: 70%-generation capacities, 65%-electric networks, 80%-heating networks (Energy Charter Secretariat, 2014).

With the growth of economic activity in industrial regions of the country, there has also been an increase in electricity consumption. The majority of energy facilities are located in the vicinity of Ekibastuz coal field (GRES-1, GRES-2, Aksu GRES), and some regions of the RK, such as the West Kazakhstan, Atyrau, and Mangystau Regions are still experiencing power shortages.

## 2. REVIEW OF LITERATURE

The review of the literature on the problems of the RES use has shown that the general term of renewable energy refers to very different energy sources (Weitzel, and Glock, 2018). On the one hand, it refers to a long and successfully operated large hydropower and, on the other hand, it is relatively new sources-such as solar energy, wind, geothermal and even quite exotic ocean wave energy (Limberger, Boxem, Pluymaekers, Bruhnc, Manzella, Calcagno et al., 2018, Freeman, Guarracino, Kalogirou, Markides, 2017, Banshwar et al., 2017a).

The most common forms of renewable energy are solar, wind, biomass, hydro, geothermal energy, and biofuels (Pokharel, Grala, Grebner, 2017, Banshwar et al., 2017a).

One of the main advantages of using RES is that they never run out, they require less maintenance costs than traditional energy generators (Grondys, 2017). Renewable energy production has minimal impact on the environment, as it virtually does not emit pollutants such as carbon dioxide (Chilvers et al., 2017).

A sufficient number of studies are devoted to the issues of justifying the economic feasibility of introducing RES. Many experts agree that the projects in the field of RES can bring economic benefits for many regions, since most of the projects are far from major urban centers and suburbs of the capital (Shakeel et al., 2017).

In addition to the listed advantages of the development of RES, experts identify a number of shortcomings. The first drawback of renewable energy is their small capacity, which prevents them from producing energy in large amounts in comparison with traditional fossil fuel generators (Kelsey and Meckling, 2018). This means

that society must either reduce energy consumption, or simply build more RES facilities. Many experts note that in order to solve energy problems, it is necessary to observe the balance of various energy sources (Nayar, 2018).

Another disadvantage of RES is unreliability and high dependence on weather conditions (Banshwar et al., 2017b). So, for example, hydro generators need rain to fill the dams to provide running water, wind generators need wind to rotate the blades, solar collectors need clear sky and sun to accumulate heat and electricity.

Despite such rapid rates of renewable energy development, there remain quite a few skeptics who doubt the stability of this trend. The main argument is that renewable energy is commercially uncompetitive, and projects with its use are unsustainable in the long term (Saavedra et al., 2018). That is, "green" energy is too expensive compared to conventional, and it develops only owing to state support (Parida et al., 2016).

## 3. METHODOLOGY

To achieve the set goal, the authors solved a number of problems:

- To estimate the potential of energy efficiency by sectors of the economy of the Republic of Kazakhstan;
- To examine the current state of RES in the Republic of Kazakhstan;
- To identify the main areas of development of RES in the Republic of Kazakhstan.

In the framework of this study, a comprehensive analysis of statistical data and analytical indicators was carried out. Tabular and graphical methods were used to visualize the results obtained.

The reviews and analytical materials of the International Energy Agency, European Energy Charter, KEGOC, and the Asian Development Bank act as information sources.

## 4. ESTIMATION OF THE ENERGY INTENSITY OF THE RK'S GDP

GDP energy intensity is the most common indicator of the economic energy efficiency. It is calculated as the ratio of primary energy consumption (coal, oil, gas, and other energy resources) to the country's real GDP.

The Republic of Kazakhstan is among the top ten countries with the highest energy intensity indicators of the economy (Figure 1).

High GDP energy intensity in Kazakhstan is partially due to a number of natural reasons:

- Severe sharply continental climate, long and cold winter.
- Prevalence of energy intensive sectors of the economy in the GDP structure.
- Vast, sparsely populated areas.
- A considerable length of transport infrastructure (oil and gas pipelines, power lines, water lines).

In general, the energy intensity of the country's GDP shows a decreasing trend, although energy consumption per capita is growing.

According to the forecasted balances of electricity and capacity for 2017-2023 from October 26, 2016, in 2017, the electricity shortage in the Republic of Kazakhstan will amount to 13.7 billion kWh.

Access to clean fuels and technologies for domestic heating, lighting and cooking is still a problem for the population of the region. Many rural residents demonstrate a high dependence on solid fuel in residential buildings, since other types of fuel are almost inaccessible.

Despite 100% electrification ratio of the country, the quality of electricity supply in terms of reliability, availability and sustainability remains one of the main problems of access to energy.

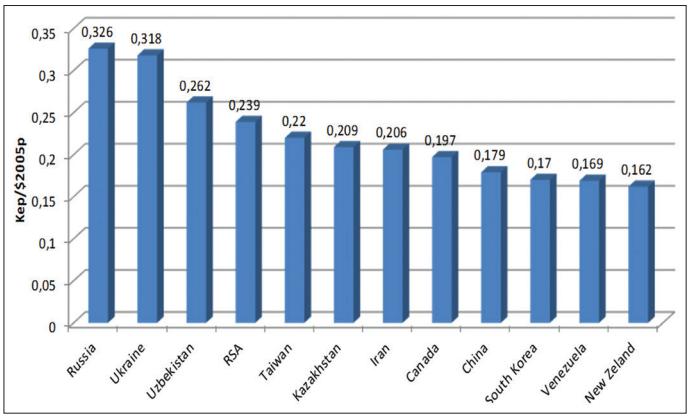
The Government of the Republic of Kazakhstan and international donors continue to promote solutions in the field of RES through initiatives to improve the quality of access to energy. The transition from donor-funded pilot projects to large-scale introduction of RES to improve the quality of access to energy in the Republic of Kazakhstan remains difficult. The main reasons for low investment activity in the implementation of renewable energy projects are the lack of financial resources in budgets of various levels; lack of local professionalism in coordinating RES projects; low popularization of effective alternative energy projects.

## 5. CURRENT SITUATION IN THE FIELD OF RES OF THE REPUBLIC OF KAZAKHSTAN

As of January 1, 2017, there are 50 enterprises operating in the country using RES with a total capacity of 295.7 MW (HPP-139.8, WPP-98.2, SPP-57.3, biogas plants-0.35 MW). For 2016, the installed renewable energy capacity in Kazakhstan increased by 18%.

In 2016, 4 renewable energy projects with a total capacity of 50.39 MW were implemented; in 2017, 12 RES facilities with installed capacity of 114.25 MW are scheduled to be implemented. The installed capacity of WPP increased by 37%-up to 98.2

**Figure 1:** Gross domestic product energy intensity indicators, kep/$ 2005p (Global Energy Statistical Yearbook, 2017)



MW, SPP-by 0.4% to 57.3 MW, biomass-based thermal power plants remained unchanged-0.4 MW, while the capacity of small hydropower plants increased by 14% to 139.9 MW.

Over the past 5 years, the share of RES in the total generation increased from 0.5% to 0.98% (Figure 2). The other 99% of electricity Kazakhstan receives from traditional sources: 79%-fuel power plants, 8%-gas-tube power plants and 12% HPP.

The growth of the RES share in the total electricity production is primarily due to such measures of state support as preferential terms for the purchase of such electricity (fixed tariffs, green certificates, etc.), priorities in connecting to power grids of generating plants producing electricity from RES, as well as in the transmission and use of electricity generated by them (Tukenov, 2016).

Within 5 years, the amount of electricity produced by RES has increased by 2.4 times (Figure 3).

The green bridge partnership program, in theory, estimates the capacity of all the country's hydro resources at 170 billion kWh per year, only 7,149.4 million kWh of which are currently used-only a small portion. In Kazakhstan, there are three large HPP-Bukhtarma, Ust-Kamenogorsk, and Shulbinsk. In addition, the Moinak HPP with a capacity of 300 MW is launched-the first and so far the only plant of this scale built for the entire period of independence.

Small hydropower plants are developing intensively, with 577.2 million kWh produced in 2016, 10% more than in 2015. By 2020, another 14 small hydropower plants are planned to be commissioned, with a total capacity of 170 MW. Thus, the combined capacity of small HPPs will increase almost five fold.

For the period of 2012-2016, the production of wind energy has increased more than 100 times. In 2016, WPP generated 275 million kWh, which is twice as much as in 2015 (Table 1).

By 2020, it is planned to launch 13 WPP with a total capacity of 793 MW-in Almaty, Jambyl, Kostanay, North Kazakhstan, Akmola, Karaganda and Aktobe Regions. The largest WPP with a capacity of 300 MW is planned to be built in the settlement of Badamsha of Kargaly district in Aktobe Region. Despite the fact that this is an unprecedented indicator for the Republic of Kazakhstan, it is fairly modest compared with other countries.

So, for example, in 2016 8.2 GW were built in the United States, 12.5 GW were commissioned in the EU. India set a national record with 3,612 MW, as stated in the GWEC report, and the total capacity of WPP in the country reached 28.7 GW (the fourth largest wind power in the world) (Global Wind Energy Council, 2017). In Brazil, 2,014 MW were built-the fifth largest growth rate in the world; here the installed capacity of wind power at the end of the year exceeded 10 GW.

The implementation of large-scale projects for the construction of new generation wind farms leads to the need to introduce the latest engineering and construction technologies, which, in turn, allows the creation of new markets. The Republic of Kazakhstan, implementing small projects of RES, loses these advantages. Until 2020, only one service project is planned for implementation: The organization of a batch production of wind power turbines with a capacity of up to 2 kW on the base of ZapadEnergoProm LLP.

In 2016, SPP increased power production by 92% to 88.4 million kWh, and bioelectric power plants increased energy production by 4 times, having generated 1.9 million kWh. Over the past 10 years, the cost of solar energy has decreased from 1.0 up

**Figure 2:** Share of renewable energy in total electricity production in the Republic of Kazakhstan, %

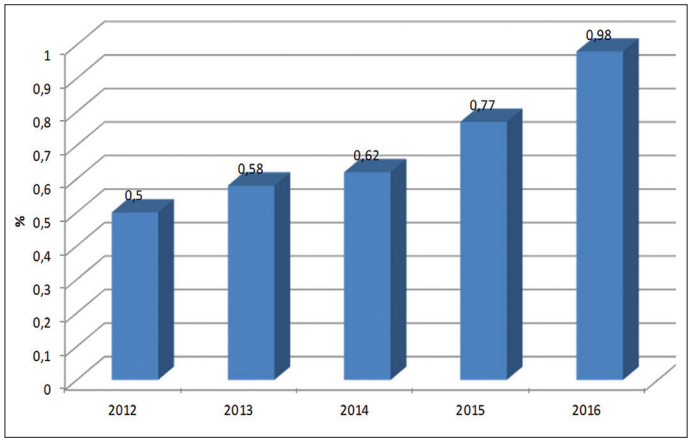



**Figure 3:** Dynamics of renewable electricity generation in the Republic of Kazakhstan in 2012-2016

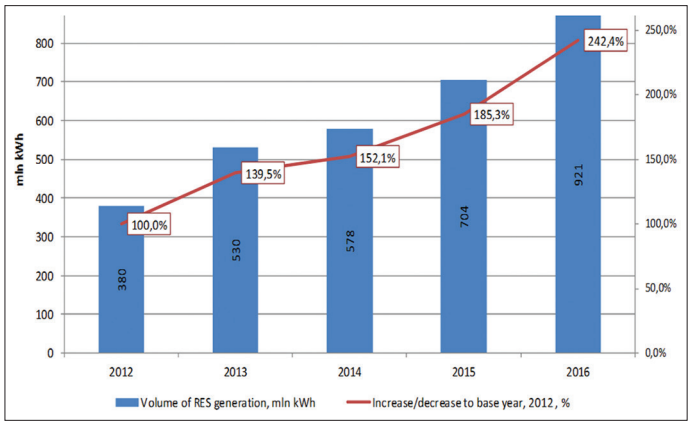



**Table 1: Indicators of electricity production of RES in the Republic of Kazakhstan in 2012-2016**

| Indicator | 2012 | 2013 | 2014 | 2015 | 2016 |
|---|---|---|---|---|---|
| Electricity produced by WPP, thous. kWh | 2,665 | 4,546.9 | 13,300.8 | 131, 722.3 | 274,982.8 |
| Electricity produced by SPP, thous. kWh | 21 | 775.8 | 1,268.3 | 46,171 | 88,403.1 |
| Electric power produced by HPP, thous. kWh | 7,637,266 | 7,730,763 | 8,262,831 | 9,269,190 | 11,620,764 |

to 0.025 USD. This was achieved through economies of scale, cheaper technologies and transition to a market-based mechanism-an auction.

By 2020, it is planned to put into operation only 4 SPPs with a total capacity 77 MW. The national action plan for sustainable energy development does not envisage service projects related to the production of equipment for solar energy.

## 6. DISCUSSION: WAYS OF RES DEVELOPMENT

Experts believe that green energy sources are becoming more competitive, and the energy sector will soon face a turning point. Existing power generating capacities-state district power plants (SDPP, or GRES), central heating power plants (CHPP) – are physically and morally obsolete (Ryskunov, 2017). One of the key indicators in the gradual transition to a green economy is energy efficiency. Kazakhstan is currently among the countries with the highest values in terms of GDP energy intensity (Vidadili, Suleymanov, Bulut, Mahmudlu, 2017).

Energy experts at Stanford University note that the use of wind, solar, geothermal and water (hydropower, tidal and wave) energy for electrification of all sectors of the economy will significantly reduce energy consumption, decrease mortality from air pollution, create millions of jobs (Shakeel et al., 2017), stabilize energy prices, and will save trillions of dollars for health care.

The creation of a new energy market involves the development and adoption of a full range of normative documents, including national standards in the field of interoperability and trade, as well as the use of best foreign practices (Afonso, Marques and Fuinhas, 2017). This will allow establishing and maintaining an open dialogue on energy security, the introduction of technologies and the implementation of effective policies among energy-producing, transit and energy-consuming countries.

As relevant problems of further development of RES in the Republic of Kazakhstan, it is possible to single out:

1. To select and implement efficient RES projects and attract the best investors with advanced technologies;
2. To reduce the cost of renewable energy and improve the energy efficiency of RES.

Kazakhstan should increase its investments in energy infrastructure projects to improve energy efficiency and integrate RES. To create favorable conditions for investments, the Government of the Republic of Kazakhstan should develop a long-term concept for the provision of sustainable energy services that supports the application of norms based on the principles of rationality and allowing producers and consumers to respond to a changing energy market.

The future energy system requires new technologies and new professional skills. Scientific research and development, the commercial introduction of new technologies, raising capital, as well as management skills are important in the transition period (Choukri, Naddami, Hayani, 2017). This requires the expansion of international cooperation and the exchange of experience.

The role of international cooperation, strategic partnership and effective functioning of energy markets and regional corridors is very significant. Exchange of experience and technologies, an increase in cross-border investments will accelerate the transition.

One of the unifying elements of such cooperation can be the development of alternative energy in the transboundary zone. The development of cross-border cooperation in energy field is crucial for achieving practical results in the development of RES on a sustainable basis.

In cases where cooperation is limited, border countries are more exposed to external shocks. The economic costs resulting from the lack of coordination can be significant. For example, in cases where it is not possible to reconcile different uses of the existing infrastructure, costly investments may be needed to duplicate or expand the infrastructure.

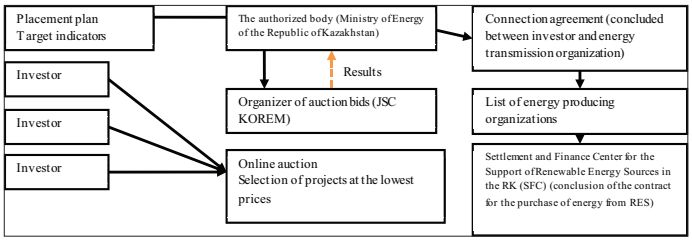
The introduction of an auction mechanism for the sector support may be an effective tool for solving problems in the implementation of RES projects. The difference between this mechanism and the mechanism based on fixed tariffs and green certificates is that: Firstly, only the suppliers of renewable energy that are selected on a competitive basis are supported, and secondly, the tariff level is determined not administratively, but on the basis of auction participants' bids.

There is a need to examine the international experience of auctioning for RES, in particular, to explore the types of contracts and types of RES auctions, define the characteristics of demand (an auction product), and examine the stages and the frequency of auctions, qualification requirements for bidders. The mechanism of auctions for RES placement is schematically shown in Figure 4.

The authorized body (Ministry of Energy of the Republic of Kazakhstan) sets the parameters of the auction (one-sided auction, marginal price; technical and financial requirements) and passes them to the bid organizer. The Ministry of Energy determines the maximum tariff. For the first auction, the maximum tariff is equal to the existing fixed tariff.

The organizer carries out pre-qualification of investors and conducts auction bids in the electronic system. The pre-

**Figure 4:** The mechanism of auctions in the future development of renewable energy sources



qualification procedure will allow assessing potential investors' ability to fulfill comprehensive contract commitments at an early stage, as well as reducing the investor's expenses for preparation of applications. The result of the auction bid is a contract for the supply of a certain amount of power or electricity produced from RES.

In conclusion, it should be noted that the use of auctions will make it possible to control the pace of RES development, plan budget for its support, as well as to determine in the empirical way acceptable rate for the purchase of electricity from RES on a competitive basis.

## 7. CONCLUSION

The conducted research of trends of RES development in the Republic of Kazakhstan allows formulating the following conclusions.

High energy intensity of the RK's GDP, depletion of RES calls for development and use of RES.

The Republic of Kazakhstan has a significant potential for the development of alternative energy. However, the share of RES in total energy production is still negligible, and the available capacities of RES facilities are not fully utilized.

Most RES projects in the RK are related to the creation of small capacity facilities, which does not allow the creation of new markets. So, the development plan for renewable energy until 2020 includes only one service project in the wind power segment, while in the solar energy sector the implementation of service projects is not planned at all.

Based on the study of the opinions of market experts, two primary priorities for the further development of renewable energy in the Republic of Kazakhstan have been singled out:

1. To select and implement efficient RES projects and attract the best investors with advanced technologies;
2. To reduce the burden of RES on the country's economy.

To solve these problems, it is necessary to create a new energy system based on RES. Creating a new energy market involves the elaboration of a long-term vision of providing sustainable energy services, as well as the implementation of a set of measures to strengthen the enabling environment, including greater investment in RES facilities.

An effective tool for supporting the renewable energy sector may become the auction mechanism, which will help to monitor the development of RES, as well as to plan a budget to support alternative energy projects.

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