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The Impact Analysis of Electricity Prices on the Energy Intensity of the Kazakhstani Economy and Sustainable Development

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ABSTRACT

The independent Kazakhstan is highly inefficient in electricity production, transmission and distribution infrastructure, while electricity prices both for industry and residential consumers is significantly lower that world average level due to abundance of oil, gas and coal resources. As a result of resource usage inefficiency, the country loss of 3-5% of national growth domestic product and competitiveness on international economic arena. The aim of this study is to determine the possibilities of ensuring economic growth in Kazakhstan by improving the energy efficiency of the economy. The paper proposes to identify the relationship between economic growth and energy efficiency in Kazakhstan by applying the correlation-regression and comparative analysis of the dynamics of the national gross product and its specific energy intensity, which will determine and substantiate the priority direction of increasing energy efficiency and sustainable development in Kazakhstan. The result of correlation-regression analysis reveals that an increase in the price of electricity supply for industry by 2.5 KZT tenge per 1 kW leads to an improvement in the energy intensity of GDP by 0.012 kg per 47,000 KZT (or 100 USD), and an increase in the price of electricity supply for the population by 2.5 KZT per 1 kW leads to an improvement in energy intensity GDP by 0.005 kg per 47,000 KZT. In discussion, the article argues that country is mostly focuses on development of renewable energy sector, while considering the situation that Kazakhstan is geographically large country with high energy losses during the transmission and distribution electricity system, the application of the Smart Grid technologies seems as a prerequisite for improvement of energy efficiency and economic growth in Kazakhstan.

Keywords: economic growth, energy efficiency, energy intensity, Smart Grid technology, Kazakhstan
JEL Classifications: C50, O10, P20

1. INTRODUCTION

The high energy intensity of the Kazakh economy slows down its national economic growth and threatens the country's economic security (Sarbassov et al., 2013; Petrenko et al., 2020). In this regard, there is a general issue of improving energy efficiency and, in particular, analyzing the relationship between energy intensity indicators and economic development (Miketa, 2001; Sadorsky, 2013). Economic growth is understood as a long-term trend towards an increase in real growth domestic product (GDP). To ensure this, appropriate national strategies are being drawn up, including in the field of energy efficiency. Energy efficiency is the sustainable and efficient usage of fossil fuel and energy resources at the existing level of technological development and environmental protection requirements (Patterson, 1996; Backlund et al., 2012). The main indicator of energy efficiency is the specific energy consumption per GDP unit of useful product in all spheres of human activity (Lenzi et al., 2013). With regard to national and regional economies, such an indicator is the energy intensity of the gross domestic product and the gross regional product. Energy efficiency is a necessary condition for the competitiveness of countries in the world economy, the fulfillment of which is ensured by the introduction of modern technologies, modernization of all spheres of economic activity, ecology, lifestyle and thinking of each person (Tanaka, 2011; Stern, 2012). Energy efficiency and sustainable economic growth are interrelated and interdependent processes. Analysis of long-term trends in the development of the world economy shows that in the future until 2050, one should expect a transition of the energy sector to a new qualitative state associated with a steady increase in energy efficiency (Rosen, 1996; Rosen, 2002). The rapid growth in energy efficiency is achieved in such ways as the integration of energy with other high-tech industries and the transition to universal energy production, including in everyday life, for example, an "passive house", which is supplied with electricity using Smart Grid and green energy technologies (Tuballa and Abundo, 2016; Mihai et al., 2017); reorganization of energy commodity markets, development of markets for energy services and markets for energy technologies (Nicolli and Vona, 2019; Pepermans, 2019); rapid development of nanotechnology and their introduction into the energy sector to improve energy efficiency (Menéndez-Manjón et al., 2011).

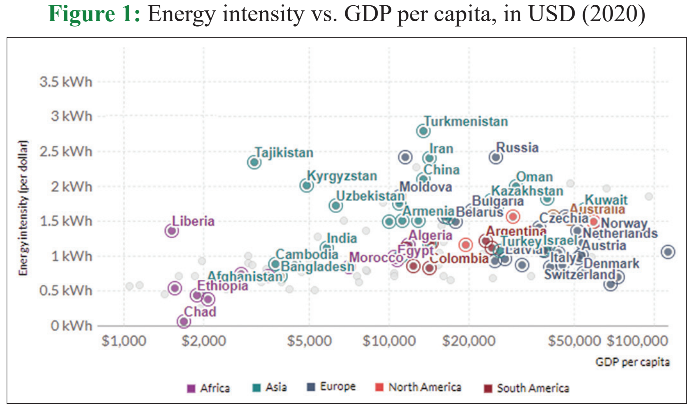
In developed market economies, national energy efficiency programs have been underway for over thirty years, which is why they are experiencing energy efficient economic growth (Bukarica and Tomšić, 2017). The 1% increase in gross domestic product accounts for no more than 0.4% of an increase in energy consumption. In Kazakhstan, in accordance with global practice, for more than five years, improving the efficiency of energy use has been considered a priority of the national economic policy (Karatayev and Hall, 2020). A quantitative indicator of achieving the required level of energy efficiency in the Kazakhstani economy should be a decrease in the specific energy intensity of GDP by 50% between 2015 and 2050 (Ongdash et al., 2020; Karatayev et al., 2021). Since 2015, Kazakhstan has taken important steps to create a legal and institutional framework for improving energy efficiency. In June 2015, the Decree of the President of the Republic of Kazakhstan "On measures to improve the energy efficiency" was published. In accordance with it, the Ministry of Energy of the Republic of Kazakhstan has developed an action plan to improve the efficiency of energy resources use in all sectors of the economy, which includes setting goals and determining measures to achieve them, developing a modern regulatory framework and creating an organizational structure (Koshim et al., 2018; Rivotti et al., 2019).

The energy intensity of the Kazakhstani economy is very high compared to developed countries and some former post-soviet countries (Figure 1) and for the period from 2010 to 2020 grew by more than 15%. At the same time, the levels of energy intensity of production of the most important domestic industrial products are 1.2-2 times higher than the world average, and in relation to the best world practices by 1.5-4 times (Kazenergy, 2020; Syzdykova et al., 2020). The State Report on the Energy Saving and Increasing Energy Efficiency for 2020 notes that the most significant factors in reducing the energy intensity of GDP for 2010–2020 became environmental and technological factors (Zhanseitov et al., 2020). At the same time, not only the level of energy intensity affect economic growth, but economic growth itself is a factor in reducing or increasing energy efficiency. In the 1990s due to the transformational recession of the economy, large industrial enterprises did not work at full capacity and, to maintain equipment in working order, consumed large basic volumes of electricity that were not directly related to production volumes, which caused an increase in the energy intensity of the gross product (Soltangazinov et al., 2020; Koulouri and Mouraviev, 2018). In the 2000s, which became a period of economic recovery by the average annual GDP growth rate was 5-6%, on the contrary: there was a monotonous decrease in the electricity intensity of GDP by an average of 3.1% per year (Kazenergy, 2020). This was caused not so much by an increase in the efficiency of energy resources use as by an increase in capacity utilization and a decrease in the corresponding electricity costs (Guliyev and Mekhdiev, 2017; Tasmaganbetov et al., 2020).

2. METHODOLOGICAL FRAMEWORK

Traditionally, the oil, gas and coal industry is the driver of the economy of Kazakhstan, and coal is the main primary source of energy. It is believed that the level of electricity supply affects the speed of implementation of technological innovations and equipment modernization among consumers. The author carried out a study of the dependence of the energy intensity of the economy on domestic prices for electricity supply. The method of correlation-regression analysis was used as a mathematical approach. The energy intensity of the gross domestic product was taken as a result factor, the average wholesale price for electricity supply for industry and the average wholesale price for electricity supply for the population are designated as independent variables. The samples for each factor are presented with actual values for 2010–2020, each sample contains 20 values. Pearson's correlation coefficient is a measure of the linear correlation between two variables (Pearson, 1895). It is calculated by using Eg. (1), in which x represents the independent variable and y represents the dependent variable.

Figure 1: Energy intensity vs. GDP per capita, in USD (2020)



$$R = \frac{\sum_{i=1}^{N}(x_i - x)(y_i - y)}{\sqrt{\sum_{i=1}^{N}(x_i - x)^2 \sum_{i=1}^{N}(y_i - y)^2}} \quad \text{(Eq. 1)}$$

The complete dependency between two variables is expressed by either -1 or +1, and 0 represents the complete independency of the variables. Pearson's correlation analysis has been employed in many studies to examine the correlation among drought indices as well as their relationships with wheat yield (Leilah and Al-Khateeb, 2005; Qaiser et al., 2021). Correlation analysis revealed a high inverse linear dependence (Pearson's linear correlation coefficient is more than 0.9 in model).

3. RESULT OUTCOMES

A regression equation is obtained that puts the energy intensity of GDP in an inverse linear relationship with prices for electricity supply for industry and the population. The obtained values of the regression coefficients allow to write the regression equation in the following form:

$$y = 185{,}10–0{,}019x_1–0{,}002x_2 \quad \text{(Eg. 2)}$$

The equation has the following meaning: an increase in the price of electricity supply for industry by 2.5 KZT tenge per 1 kW leads to a decrease in the energy intensity of GDP by 0.012 kg/47,000 KZT, and an increase in the price of electricity supply for the population by 2.5 KZT per 1 kW leads to a decrease in energy intensity GDP by 0.005 kg per 47,000 KZT. The inverse relationship means that an increase in the price of electricity supply leads to a decrease in the energy intensity of GDP. The model contains a rather strong influence of all other factors not taken into account in the model that affect the energy intensity of GDP. Their presence is expressed by the constant a_0=185,10.

In the economic interpretation of regression equations, elasticity coefficients are often used, reflecting how many percent on average the value of the effective indicator will change when the corresponding factor indicator changes by 1%:

$$Э_{xy} = – 0{,}03 \quad \text{(Eg. 3)}$$

i.e., with an increase in the price of electricity supply for industry by 1%, the energy intensity of GDP will decrease by 0.5%, and with an increase in the price of electricity supply for the population by 1%, the energy intensity of GDP will decrease by 0.04%. In Kazakhstan, indicators for monitoring and assessing the low carbon system transition, including air pollution, have been developed. In the period from 1990 to 2020, the main share of emissions of pollutants in the country falls on sulfur dioxide. The volume of emissions of pollutants from stationary sources into the air amounted to 4649.9 tons in 1990 and 2896.6 tons in 2020 (OWD, 2022). Over the past 15 years, Kazakhstan contributes to around 1% of global carbon emissions (Figure 2) and there has been a decrease in the total of carbon emissions (Figure 3) and carbon emissions per capita (Figure 4). The total emissions in 2020 amounted to 47% of the total emissions of 1990 (OWD, 2022). Specific of Kazakhstani economy also should be considered, the country has mostly industry-based economy, as result country produces more production-based carbon emission (Figure 5) in contrast to developed countries with consumption-based emissions and service -based economy (Figure 6).

Between 2000 and 2016, total water consumption in Kazakhstan increased by 10.2% (UN, 2019). In 2000 the total water consumption was 463.0 million m^3 then in 2020 the total water consumption amounted to 510 million m^3 (WB, 2020). At the same time, household water consumption per capita in Kazakhstan in 2020 compared to 2000 decreased from 31.1 up to 28.7 m^3. In the period from 2011 to 2020, there is a positive trend in the use of renewable energy sources in the generation of electricity in Kazakhstan. In 2010 the share of electricity production from energy producing organizations using renewable energy sources in the total volume of electricity production was 9.1%, then in 2020 this figure increased to 111% (REN21, 2020). Figure 7

Figure 2: Annual CO_2 emissions, 2020

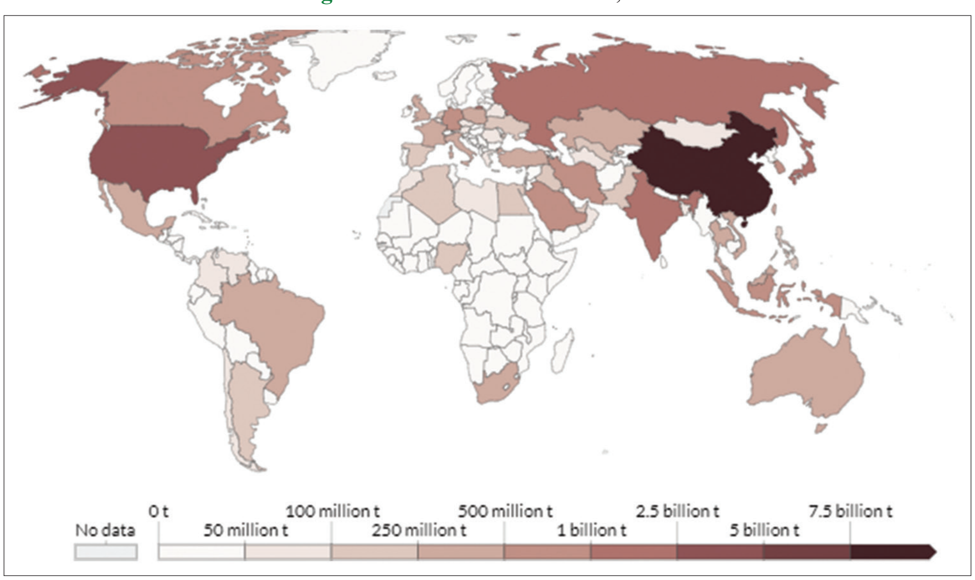


Figure 3: Annual percentage change in CO2 emissions, Kazakhstan

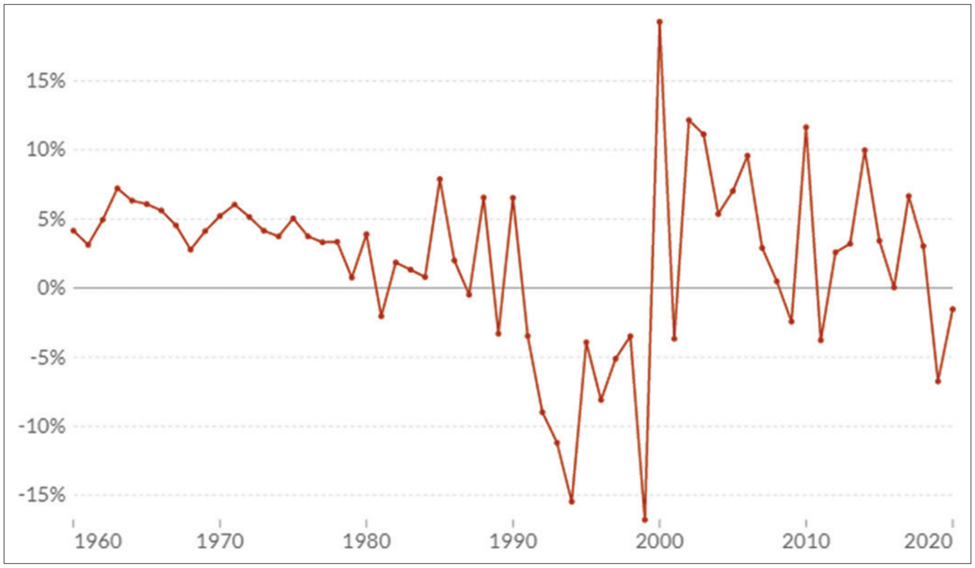


Figure 4: Per capita CO_2 emissions, Kazakhstan

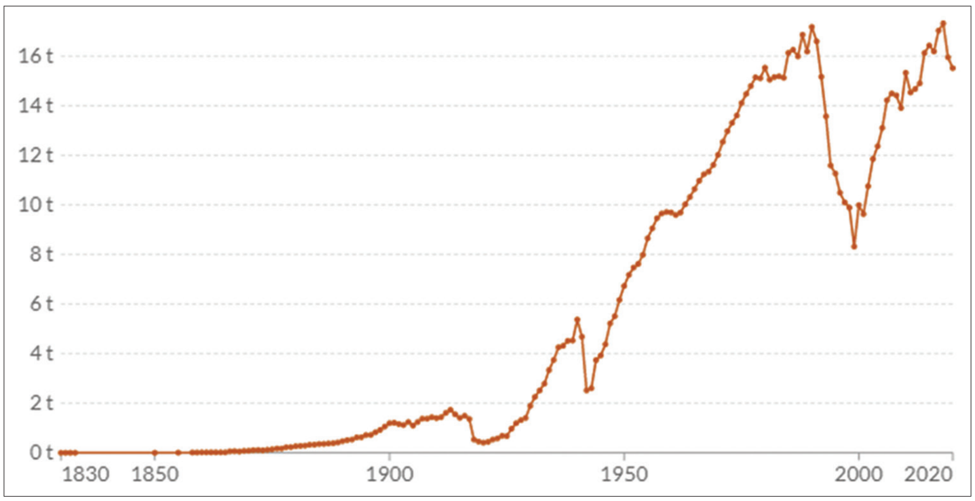


Figure 5: Production vs. consumption-based CO_2 emissions, Kazakhstan

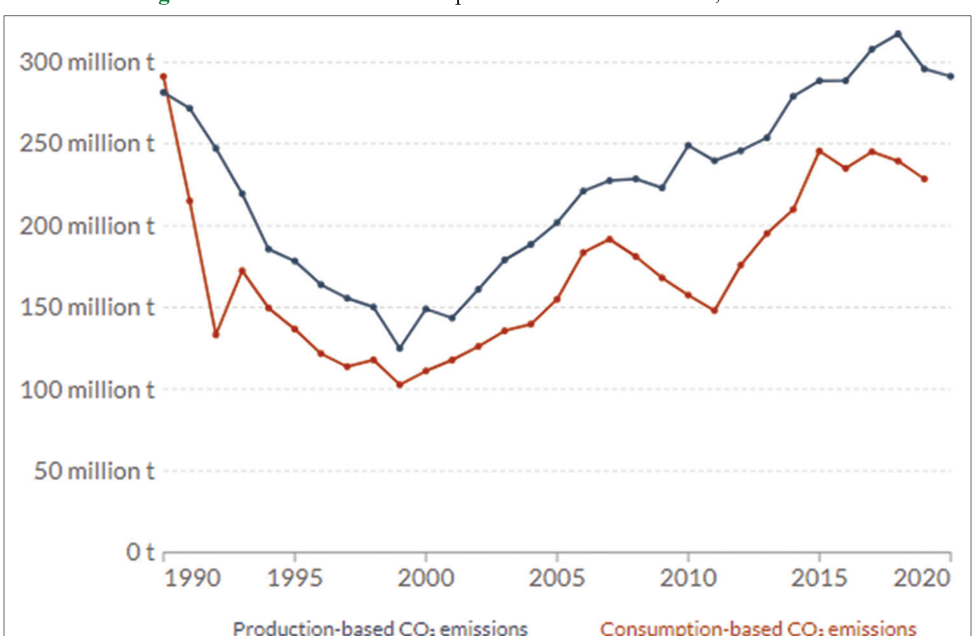


Figure 6: Consumption vs. production-based CO_2 emissions, United Kingdom

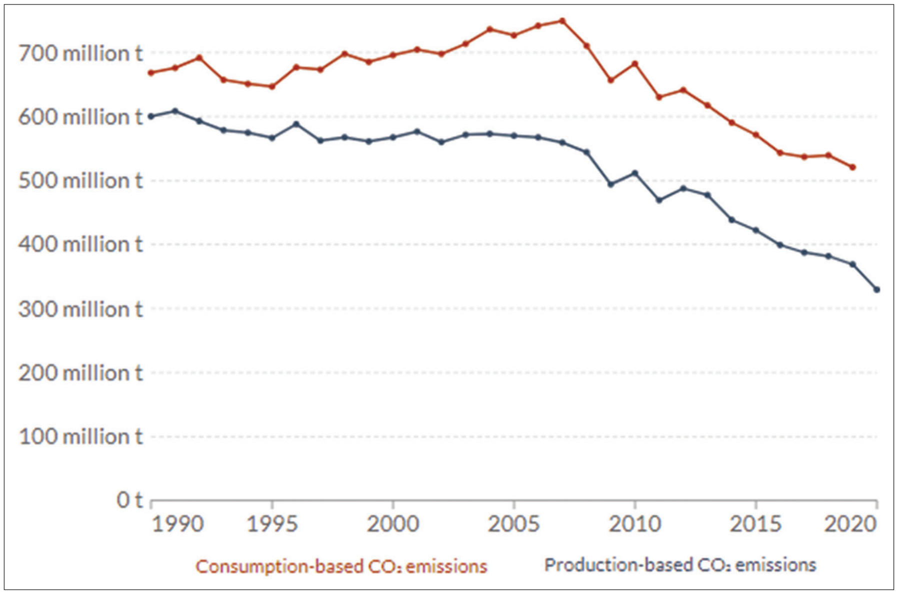


Figure 7: Electricity consumption from fossil fuels, nuclear and renewables, in % (2020)

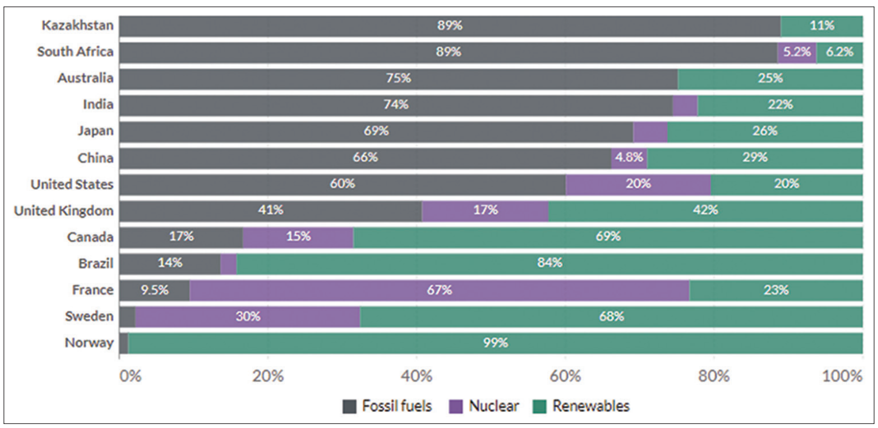
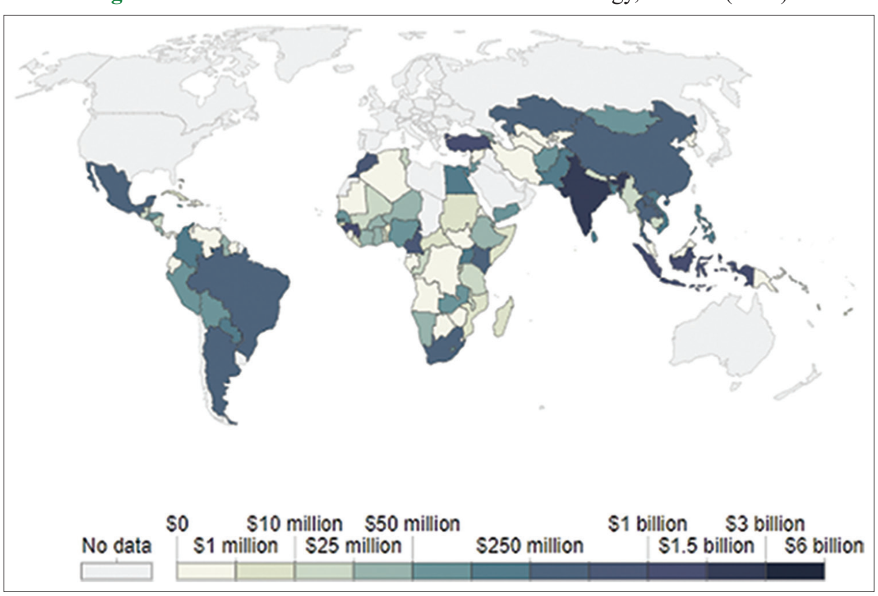


Figure 8: International finance received for clean energy, in USD (2020)



shows the share of 11% of energy consumption from renewable energy sources in the total volume of electricity, while also Kazakhstan attract a lot of investments from international donors and organizations (Figure 8), at the same time motivating domestic national public and private investors to be more active in sector of renewable energy industry.

4. CONCLUSION AND DISCUSSION

According to the results of the study, it was concluded that the negative trend of increasing tariffs in electricity supply as a whole is becoming one of the drivers for technological innovation and modernization in the electricity production industries. The calculation of the elasticity coefficients showed that the price of electricity supply for industry is 10 times more significant factor for the indicator of the energy intensity of GDP than the price of electricity supply for the population. Considering the situation that Kazakhstan is geographically large country with ineffective transmission and distribution electricity system, the application of the Smart Grid technological platform seems as a solution to country (Masera et al., 2018). In addition to solving the problems of reducing the load on the environment, reducing the energy deficit through the use of renewable energy sources, improving the quality and reliability of the power system, another very important aspect is traced in the Smart Grid concepts: Smart Grid is a catalyst for economic growth (Ringler et al., 2016; Catalão, 2017). The implementation of the provisions of this concept will imply the development of innovative technologies, the expansion of the scale of production of highly intelligent products, the more intensive use of electric energy in the transport infrastructure (the use of cars with electric motors), the development of new market relations with the involvement of consumers in the energy sector as active market players in particular the ability to sell electricity, using local generating sources (Nguyen et al., 2017; Ketter et al., 2018). Because of the implementation of the Smart Grid concept, Kazakhstan have a chance to enter a new phase of economic development, which will be characterized by harmonious interaction with the environment, improved quality of life and general economic recovery. It looks ambitious, but by no means fantastic. And this hardly contradicts domestic views on the development of energy and the country as a whole.

In Kazakhstan, the Smart Grid idea currently acts as a concept of an intelligent active-adaptive network, which can be described by the following features: saturation of the network with active elements that allow changing the topological parameters of the network; a large number of sensors that measure current operating parameters to assess the state of the network in various operating modes of the power system; data collection and processing system (software and hardware systems), as well as controls for active network elements and electrical installations of consumers; the presence of the necessary executive bodies and mechanisms that allow in real time to change the topological parameters of the network, as well as interact with adjacent energy facilities; means of automatic assessment of the current situation and construction of forecasts of the network operation; high speed of the control system and information exchange.

On the basis of these signs, it is possible to give a fairly clear definition of an intelligent network as a set of software and hardware consumers connected to generating sources and electrical installations, as well as information, analytical and control systems that ensure reliable and high-quality transmission of electrical energy from the source to the receiver at the right time and at the right time. the required amount. At the level of conceptual domestic documents, it is possible to determine the prerequisites for the development of domestic intellectual energy. According to the Energy Strategy of Kazakhstan for the period up to 2050, the following are identified as priority areas of scientific and technological progress in the electric power industry: creation of highly integrated intelligent backbone and distribution electric grids of a new generation in the Unified Energy System of Kazakhstan (smart grids - Smart Grid); the use of low-temperature superconducting induction storage of electrical energy for electrical networks and guaranteed power supply to responsible consumers; widespread development of distributed generation; development of power electronics and devices based on them, first of all, various kinds of network controlled devices (flexible AC transmission systems - FACTS); creation of a highly integrated information and control complex for operational dispatch control in real time with expert calculation systems for decision-making; creation of highly reliable backbone communication channels between different levels of dispatch control and duplicated digital channels of information exchange between objects and control centers; creation and widespread implementation of centralized emergency management systems covering all levels of the Unified Energy System of Kazakhstan; creation of automated power demand management systems; creation of hydrogen energy storage systems and coverage of irregularities in the load schedule.

As for policy framework, Kazakhstan has joined all initiatives of the United Nations: 1. The document "The future we want", signed in 2012 in Rio de Janeiro, which states that human development is associated with the transition to sustainable development; 2. The document "Transforming our world: the 2030 Agenda for Sustainable Development", signed in 2015. The document "Sustainable Development Goals" was adopted: 17 goals, objectives, indicators, that is, a quantitative interpretation of sustainable development humanity and individual countries; 3. The Paris Agreement, adopted by all 196 parties to the United Nations Framework Convention on Climate Change at the 21st Conference in 2015, which provides a roadmap for measures to reduce emissions and strengthen resilience to climate change. In the post-Soviet space, for scientists, economists, society, and the concept of "sustainable development" is economic growth based on indicators of gross domestic product.

The concept of sustainable development is a complex structure, which consists in the balanced development of three components: economic, social and environmental components (Ciegis et al., 2009; Demirtas, 2013). The concept of sustainable development was formed as a result of the combination of three directions: 1) Economic direction. As a result, economic projects that take into account the laws of nature are more effective than projects that do not take into account possible environmental consequences (Despotovic et al., 2016); 2) Environmental direction. Stability of physical and ecological systems. Ignoring the needs of the environment will lead to environmental degradation and endanger the existence of all mankind (Balderjahn et al., 2013; Strezov et al., 2017); 3) Social direction. Awareness of social problems was the impetus for the formation of this concept, aimed at preserving cultural and social stability, as well as reducing the number of destructive conflicts (Pearce and Atkinson, 1998; Dempsey et al., 2011). Currently, the world is experiencing unequal development of these areas. The task of sustainable development is to make these directions equal and to maximize the area of their intersection. In connection with the concept of sustainable development, many terms have appeared in science and economics, such as low carbon economy. Kazakhstan is a country that bases its development on carbon resources (coal, oil, gas). For Kazakhstan, a low carbon economy is a low energy intensity economy.

Another trend is a divestment, i.e., the process of withdrawing investments, capital investments from traditional economic sectors to new ones in particular to low-carbon ones, is gaining momentum in the world (Bergman, 2018). For example, the Norwegian Pension Fund is one of the richest financial institutions in the world. Norway is a country on the hydrocarbon needle. The Norwegian Pension Fund began to transfer resources from traditional energy and distribute it to renewable energy sources, to various kinds of green industries, and this process is going on all over the world (Rimmer, 2016; Sjafjell et al., 2017). The global economy is beginning to transfer resources from traditional carbon-intensive industries to new industries. The third trend, which is related to sustainable development, is the decoupling, which means an increase in the final results while reducing the consumption of natural resources and the production of pollution, obtaining a greater economic result with a minimum of environmental impact (Mielnik and Goldemberg, 2002; Schandl et al., 2016). In this regard, the term green economy appeared. A green economy is an economy that conserves natural capital and minimizes greenhouse gas emissions, uses natural resources rationally, conserves ecosystems, their services and biodiversity, and thus generates income and employment growth (Borel-Saladin and Turok, 2013; Loiseau et al., 2016).

National approaches to formulating energy security policies differ depending on the availability of natural resources, natural and climatic conditions, geographic location and geopolitical environment (Guliyev, 2021). Energy security concepts may not only differ, but also be contradictory in different countries. This is noticeable in the example of Russia, which considers the global trend towards the transition to alternative energy sources as a threat to its energy security, on the one hand, and on the other hand, Sweden and Lithuania, which do not possess a large amount of natural resources, strive to ensure energy independence through the transition to green energy (Kaveshnikov, 2010; Senderov and Edelev, 2019). In many countries, the problem of ensuring energy security is an important issue, which is expressed in the adoption of individual program and strategic documents. In the major energy powers of the United States and Russia, there are separate institutions dealing with energy security issues. In Kazakhstan, unlike most of the countries considered, there are no separate program documents on energy security, as well as separate institutions, while the risk for the country's energy security is considered low.

5. ACKNOWLEDGMENT

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REFERENCES

Backlund, S., Thollander, P., Palm, J., Ottosson, M. (2012), Extending the energy efficiency gap. Energy Policy, 51, 392-396.

Balderjahn, I., Buerke, A., Kirchgeorg, M., Peyer, M., Seegebarth, B., Wiedmann, K.P. (2013), Consciousness for sustainable consumption: Scale development and new insights in the economic dimension of consumers' sustainability. AMS Review, 3(4), 181-192.

Bergman, N. (2018), Impacts of the fossil fuel divestment movement: Effects on finance, policy and public discourse. Sustainability, 10(7), 2529.

Borel-Saladin, J.M., Turok, I.N. (2013), The green economy: Incremental change or transformation? Environmental Policy and Governance, 23(4), 209-220.

Bukarica, V., Tomšić, Ž. (2017), Energy efficiency policy evaluation by moving from techno-economic towards whole society perspective on energy efficiency market. Renewable and Sustainable Energy Reviews, 70, 968-975.

Catalão, J.P., editors. (2017), Smart and Sustainable Power Systems: Operations, Planning, and Economics of Insular Electricity Grids. Florida, United States: CRC Press.

Ciegis, R., Ramanauskiene, J., Martinkus, B. (2009), The concept of sustainable development and its use for sustainability scenarios. Engineering Economics, 62(2), 1-10.

Demirtas, O. (2013), Evaluating the best renewable energy technology for sustainable energy planning. International Journal of Energy Economics and Policy, 3(S), 23-33.

Dempsey, N., Bramley, G., Power, S., Brown, C. (2011), The social dimension of sustainable development: Defining urban social sustainability. Sustainable Development, 19(5), 289-300.

Despotovic, D., Cvetanovic, S., Nedic, V., Despotovic, M. (2016), Economic, social and environmental dimension of sustainable competitiveness of European countries. Journal of Environmental Planning and Management, 59(9), 1656-1678.

Guliyev, F. (2021), Monitoring Energy Transitions in Eurasia (Azerbaijan, Kazakhstan, Kyrgyzstan, and Ukraine): Analysis and Policy Implications. Eurasia Extractive Industries Knowledge Hub (Eurasia Hub) in Collaboration with Khazar University.

Guliyev, I.A., Mekhdiev, E.T. (2017), The role of fuel and energy sector in the Eurasian economic community integration process. International Journal of Energy Economics and Policy, 7(2), 72-75.

Honma, S., Hu, J.L. (2014), Industry-level total-factor energy efficiency in developed countries: A Japan-centered analysis. Applied Energy, 119, 67-78.

Karatayev, M., Hall, S. (2020), Establishing and comparing energy security trends in resource-rich exporting nations (Russia and the Caspian Sea region). Resources Policy, 68, 101746.

Karatayev, M., Lisiakiewicz, R., Gródek-Szostak, Z., Kotulewicz-Wisińska, K., Nizamova, M. (2021), The promotion of renewable energy technologies in the former Soviet bloc: Why, how, and with what prospects? Energy Reports, 7, 6983-6994.

Kaveshnikov, N. (2010), The issue of energy security in relations between Russia and the European Union. European Security, 19(4), 585-605.

Ketter, W., Collins, J., Saar-Tsechansky, M., Marom, O. (2018), Information systems for a smart electricity grid: Emerging challenges and opportunities. ACM Transactions on Management Information Systems (TMIS), 9(3), 1-22.
Koshim, A., Karatayev, M., Clarke, M.L., Nock, W. (2018), Spatial assessment of the distribution and potential of bioenergy resources in Kazakhstan. Advances in Geosciences, 45, 217-225.
Koulouri, A., Mouraviev, N. (2018), Governance of the clean energy sector in Kazakhstan: Impediments to investment. International Journal of Technology Intelligence and Planning, 12(1), 6-23.
Leilah, A.A., Al-Khateeb, S.A. (2005), Statistical analysis of wheat yield under drought conditions. Journal of Arid Environments, 61(3), 483-496.
Lenzi, C., Bragalli, C., Bolognesi, A., Artina, S. (2013), From energy balance to energy efficiency indicators including water losses. Water Science and Technology: Water Supply, 13(4), 889-895.
Loiseau, E., Saikku, L., Antikainen, R., Droste, N., Hansjürgens, B., Pitkänen, K., Thomsen, M. (2016), Green economy and related concepts: An overview. Journal of Cleaner Production, 139, 361-371.
Masera, M., Bompard, E.F., Profumo, F., Hadjsaid, N. (2018), Smart (electricity) grids for smart cities: Assessing roles and societal impacts. Proceedings of the IEEE, 106(4), 613-625.
Menéndez-Manjón, A., Moldenhauer, K., Wagener, P., Barcikowski, S. (2011), Nano-energy research trends: Bibliometrical analysis of nanotechnology research in the energy sector. Journal of Nanoparticle Research, 13(9), 3911-3922.
Mielnik, O., Goldemberg, J. (2002), Foreign direct investment and decoupling between energy and gross domestic product in developing countries. Energy Policy, 30(2), 87-89.
Mihai, M., Tanasiev, V., Dinca, C., Badea, A., Vidu, R. (2017), Passive house analysis in terms of energy performance. Energy and Buildings, 144, 74-86.
Miketa, A. (2001), Analysis of energy intensity developments in manufacturing sectors in industrialized and developing countries. Energy Policy, 29(10), 769-775.
Nguyen, D.B., Scherpen, J.M., Bliek, F. (2017), Distributed optimal control of smart electricity grids with congestion management. IEEE Transactions on Automation Science and Engineering, 14(2), 494-504.
Nicolli, F., Vona, F. (2019), Energy market liberalization and renewable energy policies in OECD countries. Energy Policy, 128, 853-867.
Ongdash, A.O., Omirtay, A.D., Bayetova, M.T., Ongdashuly, E. (2020), Economic growth modeling for the republic of Kazakhstan based on the higher energy efficiency level. International Journal of Energy Economics and Policy, 10(6), 396.
OWD. (2022), Energy Section, Our World in Data. Available from: https://www.ourworldindata.org
Patterson, M.G. (1996), What is energy efficiency?: Concepts, indicators and methodological issues. Energy Policy, 24(5), 377-390.
Pearce, D., Atkinson, G. (1998), The concept of sustainable development: An evaluation of its usefulness ten years after Brundtland. Revue Suisse d Economie Politique et de Statistique, 134, 251-270.
Pearson, K. (1895), Notes on regression and inheritance in the case of two parents. Proceedings of the Royal Society of London, 58, 240-242.
Pepermans, G. (2019), European energy market liberalization: Experiences and challenges. International Journal of Economic Policy Studies, 13(1), 3-26.
Petrenko, Y., Denisov, I., Koshebayeva, G., Biryukov, V. (2020), Energy efficiency of Kazakhstan enterprises: Unexpected findings. Energies, 13(5), 1055.
Qaiser, G., Tariq, S., Adnan, S., Latif, M. (2021), Evaluation of a composite drought index to identify seasonal drought and its associated atmospheric dynamics in Northern Punjab, Pakistan. Journal of Arid Environments, 185, 104332.
REN21. (2020), Renewables 2020. Global Status Report. Renewable Energy Policy Network for the 21st Century. Available from: https://www.ren21.net/publications
Rimmer, M. (2016), Investing in the future: Norway, climate change, and fossil fuel divestment. In: Atkins, E.D., editors. In: Environment, Climate Change and International Relations: Tendencies, Assessments and Perspectives, E-International Relations. p206-225.
Ringler, P., Keles, D., Fichtner, W. (2016), Agent-based modelling and simulation of smart electricity grids and markets-a literature review. Renewable and Sustainable Energy Reviews, 57, 205-215.
Rivotti, P., Karatayev, M., Mourão, Z.S., Shah, N., Clarke, M.L., Konadu, D.D. (2019), Impact of future energy policy on water resources in Kazakhstan. Energy Strategy Reviews, 24, 261-267.
Rosen, M.A. (1996), Energy efficiency and sustainable development. IEEE Technology and Society Magazine, 15(4), 21-26.
Rosen, M.A. (2002), Energy efficiency and sustainable development. International Journal of Global Energy Issues, 17(1-2), 23-34.
Sadorsky, P. (2013), Do urbanization and industrialization affect energy intensity in developing countries? Energy Economics, 37, 52-59.
Sarbassov, Y., Kerimray, A., Tokmurzin, D., Tosato, G., De Miglio, R. (2013), Electricity and heating system in Kazakhstan: Exploring energy efficiency improvement paths. Energy Policy, 60, 431-444.
Schandl, H., Hatfield-Dodds, S., Wiedmann, T., Geschke, A., Cai, Y., West, J., Owen, A. (2016), Decoupling global environmental pressure and economic growth: Scenarios for energy use, materials use and carbon emissions. Journal of Cleaner Production, 132, 45-56.
Senderov, S.M., Edelev, A.V. (2019), Formation of a list of critical facilities in the gas transportation system of Russia in terms of energy security. Energy, 184, 105-112.
Sjafjell, B., Nilsen, H.R., Richardson, B.J. (2017), Investing in sustainability or feeding on stranded assets: The Norwegian government pension fund global. Wake Forest Law Review, 52, 949.
Soltangazinov, A., Smagulova, Z., Amirova, M., Kashuk, L., Karimbergenova, M., Kadyrova, A., Zhaltyrova, O. (2020), Energy efficiency as a factor of sustainable development in Kazakhstan. International Journal of Energy Economics and Policy, 10(1), 325.
Stern, D.I. (2012), Modeling international trends in energy efficiency. Energy Economics, 34(6), 2200-2208.
Strezov, V., Evans, A., Evans, T.J. (2017), Assessment of the economic, social and environmental dimensions of the indicators for sustainable development. Sustainable Development, 25(3), 242-253.
Syzdykova, A., Azretbergenova, G., Massadikov, K., Kalymbetova, A., Sultanov, D. (2020), Analysis of the relationship between energy consumption and economic growth in the commonwealth of independent states. International Journal of Energy Economics and Policy, 10(4), 318-324.
Tanaka, K. (2011), Review of policies and measures for energy efficiency in industry sector. Energy Policy, 39(10), 6532-6550.
Tasmaganbetov, A.B., Kunurkulzhayeva, G.T., Imanbayeva, Z.O., Ataniyazov, Z., Shaikin, D.N. (2020), Future development of price instruments of state support for the use of renewable energy sources in Kazakhstan. International Journal of Energy Economics and Policy, 10(1), 140-144.
Tuballa, M.L., Abundo, M.L. (2016), A review of the development of Smart Grid technologies. Renewable and Sustainable Energy Reviews, 59, 710-725.
UN. (2019), Tracking SDG7: The Energy Progress Report, United Nations. Available from: https://www.sustainabledevelopment.un.org/content
WB. (2020), World Development Report 2021: Data for Better Lives. Washington, DC: World Bank. Available from: https://www.openknowledge.worldbank.org
Zhanseitov, A., Raikhanova, G., Mambetova, S., Daribekov, S., Akbayev, Y. (2020), The influence of fiscal progress on energy consumption in Kazakhstan. International Journal of Energy Economics and Policy, 10(5), 344-347.