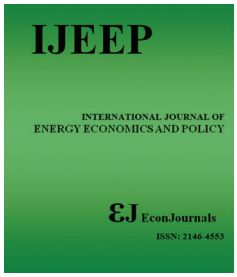

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Problems and Perspectives of Energy Security of Single - Industry Towns of the Republic of Kazakhstan

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ABSTRACT

The article considers the place and role of single-industry towns of the Republic of Kazakhstan in the country's electric power system. These zones of electricity usage are analysed by production and consumption of electricity by Kazakhstan's single-industry towns. The article also describes the factors affecting the energy security of single-industry towns among which the production factors that might trigger reduction in energy supply as a result of low-quality coal. There are some other factors underlined in the article. The main directions for ensuring the energy security of single-industry towns have been identified by energy zones.

Keywords: Energy Security, Kazakhstan, Electric Power System
JEL Classifications: Q4, Q48

1. INTRODUCTION

At the present stage of development, the system of management of the fuel and energy complex (FEC) of Kazakhstan is undergoing active transformations. One of the elements of broad socioeconomic modernization program of the economy is an increase of the energy security level. This problem is recognized to be the primary one that predetermines a long-term state development strategy. Furthermore, the solution of the issues of energy security management as one of the most important links in the economically sustainable development of FEC is due to the ever-growing threats to national economic security caused by the increased influence of the energy factor.

According to the National Energy Association KAZENERGY Report (2017), installed and available generation capacity in Kazakhstan is steadily growing because of the introduction of new coal, hydro and gas turbine capacity. Despite the regular repairs of existing power plants and commissioning of about 30% of new capacity in 2001, most of the generating capacities fleet in Kazakhstan are still based on an aging Soviet technology. Besides, about 39% of Kazakhstan single-industry towns were built before 1980 and in 2016 42% of steam turbines exceeded the planned service life.

In this regard, instability in ensuring the energy security of the single-industry towns of the Republic of Kazakhstan can have a negative impact on the initiated radical transformation of the country's economy, thereby slowing them down, or significantly increasing costs for solving of these issues.

Consequently, the main objective of this study is to analyze the current state of the single-industry towns of the Republic of Kazakhstan in the production and consumption of energy resources and suggest ways to further improve them in ensuring the country's energy security.

In order to better determine the central issue of the article, it is necessary to solve the following tasks:

- Explore the views of scientists in the sphere of "energy security;"

- Determine the role of single-industry towns in the country's electric power system;
- Describe the factors affecting the energy security of single-industry towns;
- To offer the main directions of development.

2. LITERATURE REVIEW

The existing body of recent researches on the energy security in Kazakhstan concerns different aspects: The resources (oil, gas, coal, nuclear and renewable) and their sustainable management; investment policy and pricing; international relations between national market players and transnational corporations; and energy systems and their infrastructural and technological aspects (Palazuelos and Fernández, 2012; Parag, 2016; Dudin et al., 2017; Obadi and Korcek, 2017). At the same time, some other authors denote the abundance of mineral resources of Kazakhstan (Karatayev et al., 2017) and its "significant renewable potential from wind, solar, hydro and biomass" (Karatayev and Clarke, 2014), on the one hand, and determine the risk of Dutch disease (Palazuelos and Fernández, 2012) because of Kazakhstan's economy dependence of fossil energy (Ospanova, 2014; MacGregor, 2017), on the other hand. Despite all necessary climatic and natural conditions for the adoption of new types of renewable energy resources, Kazakhstan needs broad and flexible regulatory support mechanisms and investment incentives in that area (Karatayev and Clarke, 2014). In those conditions, energy security still is a very important objective of energy policy in Kazakhstan, along with efficiency and sustainability (Labandeira and Manzano, 2012).

3. ROLE OF SINGLE-INDUSTRY TOWNS IN THE COUNTRY'S ELECTRIC POWER SYSTEM

The unified power system of the Republic of Kazakhstan consists of a set of electric stations, power transmission lines, and substations that provide reliable and high-quality power supply.

In turn, the power industry includes the electricity and heat production, transmission, supply and is the basis for the economy functioning and the life support of the country.

For the economy of the Republic of Kazakhstan, the electric power sector is of particular importance, since the key industries of the country, such as metallurgy, oil, and gas production are characterized by high energy intensity. Therefore, the competitiveness of Kazakhstan's heavy industry and the living standards largely depend on the reliable and high-quality power supply at affordable prices.

According to Analytical information of the Ministry of Energy of the Republic of Kazakhstan (2016), production of electric power in Kazakhstan is conducted by 76 power plants of different ownership. On the balance sheet of the national electrical services company, Kazakhstan Electricity Grid Operating Company, there are 297 power lines with a voltage of 35–1150 kW, the total length of which is about 31,000 km (in chains). Furthermore, there are 74 substations with a voltage of 35–1150 kW.

Information on production and consumption of electricity in the Republic of Kazakhstan for 2011–2015 is presented in Table 1.

In 2015, electricity production in Kazakhstan in comparison with 2014 decreased by 3.75% and amounted to 91 645 GWh. The decrease of electricity generation was impacted by the overabundance formed in 2013 (5726 GWh) and 2014 (3553) respectively, as well as the planned reduction of electricity consumption by industrial consumers.

As a measure to enhance energy security, the bandwidth between Northern and Southern regions was doubled (through the construction of additional 500 kW line), which resulted in the Southern region independence from the imports from Central Asia. Since 2000 the electricity flows from the Northern region tripled (from 2.5 bln. KWh in 2000 to 7.5 bln. KWh in 2016), as long as net flows of electricity from Central Asia changed radically. For that reason, Kazakhstan has become a net exporter of electricity. The construction of another 500 kW line between the Northern and Southern regions is nearing completion and expected to connect the Almaty region not only with more maneuverable capacity of Kazakhstan main hydroelectric power stations (Shulba HES [702 MW] Bukhtarma HES [675 MW] and Ust-Kamenogorsk HES [MW 331]) but also increase access to facilities of Ekibastuz-1 and-2 (5000 MW).

Nonetheless, the significant network investments ameliorated the connection between regions, the Western region remains isolated from the Northern and Southern. Moreover, it still relies on interconnections with Russia to ensure the reliability of electricity supply. But despite the sustainable growth of the electric power consumption in Western region, net imports from Russia has been steadily declining since independence in 1991. In those days the electricity import amounted to more than 50% (4551.4 GWh) the requirements of the Western region, whereas in 2015 it declined by 1% (154 GWh).

A significant role in the electricity production is played by power stations of single-industry towns, where more than 50% of the country's electricity is generated (Figure 1).

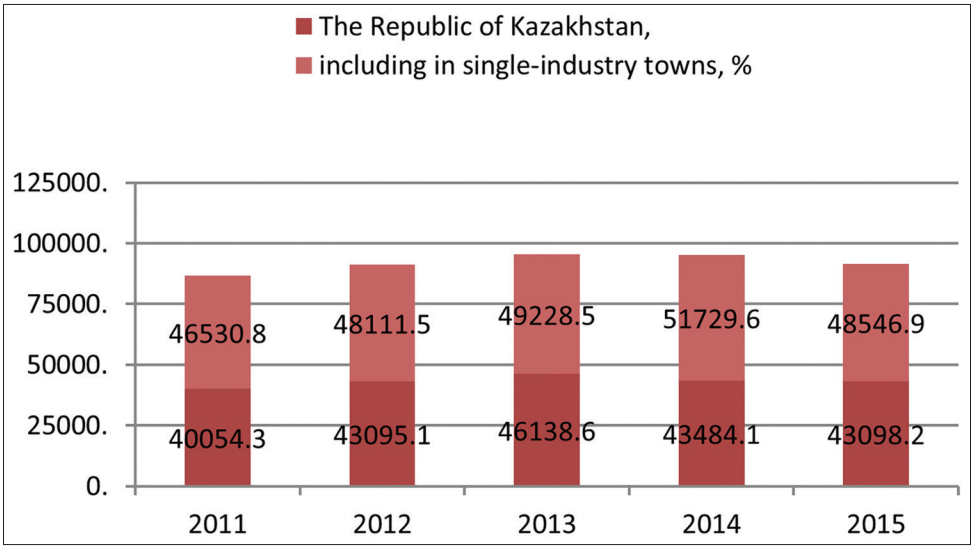
In consonance with the Statistics Committee and the Ministry of National Economy of the Republic of Kazakhstan (2016), the list

Table 1: Electricity production and consumption in Kazakhstan

Indicators	2011	2012	2013	2014	2015
Production of electricity, GWh	86585	91207	95367	95214	91645
Electricity consumption, GWh	88136	91444	89641	91661	90847
Deficiency (surplus), GWh	−1551	−237	+5726	+3553	+798

Source: Compiled by the authors on the Fuel and Energy Balance of the Republic of Kazakhstan (2016), the Committee of Statistics of the Ministry of National Economy of the Republic of Kazakhstan and the National Energy Report (2017). The Kazakhstan Association of Oil-Gas and Energy Sector Organizations "KAZENERGY."

Figure 1: Electricity production in the single-industry towns of the Republic of Kazakhstan for 2011–2015, mln kWh



Source: Compiled by the authors on the Fuel and Energy Balance of the Republic of Kazakhstan (2016), Committee of Statistics of the Ministry of National Economy of the Republic of Kazakhstan and Regions of Kazakhstan (2016), the Committee of Statistics of the Ministry of National Economy of the Republic of Kazakhstan.

of single-industry towns includes 27 towns, populated by 1.447 million people, or 16.8% of the urban population of the country.

Classification of single-industry towns of the Republic of Kazakhstan by industry characteristics is presented in Table 2.

The single-industry towns of the Republic of Kazakhstan mainly concentrate city-forming enterprises of the extractive sector (mining of coal, oil and gas, metal ores and other raw materials). In 19 out of 27 single-industry towns, there are large power stations not only of industrial importance, but also 5 power plants of national importance, which provide the electricity generation and sale to consumers in the wholesale market of the Republic of Kazakhstan.

According to the Concept of development of FEC of the Republic of Kazakhstan till 2030 (2014) energy system of the Republic of Kazakhstan is conventionally divided into three zones-Northern, Southern and Western. Based on this classification, we divided Kazakhstan's single-industry towns into the energy zones (Table 3).

As seen from Table 3 the Northern zone is energy-surplus (GWh 3877.2 2015 a year), since the power plants are concentrated mainly in this zone. The construction of thermal power plants was a practical choice in the Northern zone of Kazakhstan because of the abundance of cheap local coal.

On the contrary, power plants of single-industry towns in the Western zone are fully operating on gas, and since 1996 they steadily increase power gas turbines, due to oil and gas industry activities. Even so, single-industry towns of the Western zone still depend on Russia in regard to energy supply.

Besides that, there is a shortage of electricity in the Southern zone (−3359.2 GWh in 2015). This zone imports coal, gas, fuel oil and electricity from other regions of Kazakhstan.

Electricity is mainly produced by thermoelectric powers of single-industry towns of Kazakhstan (Table 4).

As reported by the National Association KAZENERGY Energy Report (2017), the present deterioration level of power plants is about 70%. At the beginning of 2016, the average lifespan of thermal power stations was 30.8 years, the hydropower plants-37.7 years. Simultaneously, 57% of the power plants' capacity have been in operation for more than 30 years.

Obsolete technologies applied in power plants are a consequence of low energy efficiency of the industry, on the one hand, and a large amount of environment pollution, on the other hand. Thermal power plants are one of the main greenhouse gas emission sources in Kazakhstan. According to the analytical information of the Ministry of Energy of the Republic of Kazakhstan (2016), the share of this sector is about 43% of the total greenhouse gas emissions in the country.

Hydroelectric power plants are of critical importance in the electricity production in Kazakhstan (about 10% in 2015). In addition to the fact that hydropower industry provides a base-load, it is usually used to meet peak demand. Nevertheless, the hydroelectric power stations operation can be limited to water regime and, therefore, not always be available when necessary. Besides, the power plant may have an unprofitable geographic location.

4. FACTORS AFFECTING THE ENERGY SECURITY OF SINGLE-INDUSTRY TOWNS

The energy security of single-industry towns is determined by their ability to integrate into the national economy, as well as depends on the development of the energy infrastructure. The latter meets environmental problems since it is the FEC that causes environmental pollution.

Table 2: Classification of single-industry towns by sectoral orientation

#	Branches of the economy	Number of single-industry towns	Number of stations, which produce electricity in the single-industry towns
1	Processing and chemical industries	1	1
2	Metallurgical industry	4	4
3	Coal mining	4	4
4	Oil and gas	3	3
5	Mining of metallurgical ore	10	5
6	Extraction of other raw materials	4	1
7	Science and experiment center	1	1
	Total	27	19

Source: Compiled by the authors for development programs in the region until 2020 (2014) and the Regions of Kazakhstan (2016), Committee of Statistics of the Ministry of National Economy of the Republic of Kazakhstan

Table 3: Electricity production and consumption by Kazakhstan's single-industry towns in 2015

#	Energy zones	Power sources	Number of single-industry towns	Number of power plants	Production of electricity, GWh	Consumption of electricity, GWh	Deficiency (surplus) GWh
1	Northern zone	Thermoelectric power station, hydroelectric power station	19	12	36215.0	32337.8	+3877.2
2	Western zone	Thermal power plants	4	3	5778.1	5870.8	−92.7
3	Southern zone	Thermoelectric power station, hydroelectric power station	4	4	6553.8	9913.0	−3359.2
	Total		27	19	48546.9	48121.6	+425.3

Source: Compiled by the authors on the Energy balance of the Republic of Kazakhstan (2016), Committee of Statistics of the Ministry of National Economy of the Republic of Kazakhstan, Regions of Kazakhstan (2016), the Committee of Statistics of the Ministry of National Economy of the Republic of Kazakhstan, National Energy Report (2017), the Kazakhstan Association of Oil-Gas and Energy Sector Organizations "KAZENERGY"

Table 4: Production of electricity by power plants in the single-industry towns of Kazakhstan for 2015

Type of energy plant	Amount	Power generation		Average lifespan of equipment, years
		GWh	Share (%)	
Thermal power plants	16	48101.3	90.2	30.8
Hydroelectric power stations	3	445.6	9.8	37.7
Total	19	48546.9	100	-

Source: Compiled by the authors on the Energy balance of the Republic of Kazakhstan (2016), Committee of Statistics of the Ministry of National Economy of the Republic of Kazakhstan, Regions of Kazakhstan (2016), the Committee of Statistics of the Ministry of National Economy of the Republic of Kazakhstan, National Energy Report, 2017, the Kazakhstan Association of Oil-Gas and Energy Sector Organizations "KAZENERGY"

In our opinion, the main threats to the energy security of the single-industry towns of the Republic of Kazakhstan in the current conditions are as follows:

- Irrational structure of energy resources production and export, their excessive orientation to the commodity sphere;
- A high share of coal in the production of heat and electricity;
- Operation of low-efficiency equipment that reduces the competitiveness of products;
- Excessive wear of technological equipment;
- Accidents of anthropogenic nature on power equipment;
- Environmental disasters and negative environmental consequences caused by power plant.

An alternative to the aforementioned trends should be fundamentally new benchmarks of the state energy policy aimed at regulating the energy security of single-industry towns. Therefore, when implementing the state energy policy, the following main factors that can affect the energy security of single-industry towns of the Republic of Kazakhstan should be taken into account:

- Technical factors. Backward technology and equipment, high depreciation of fixed assets, lead to increased economic losses of power plants. Procurement of the main equipment is conducted from abroad; its transportation and installation can lead to interruptions of heat and electricity supply;
- Natural factors. A low water level can lead to the inoperability of hydroelectric power stations;
- Production factors. The power plants mainly consume coal. In case of low-quality coal supply, the boiler units will break down and, as a consequence, stop the entire station;
- Environmental factors. These factors include the difficulties caused by the depletion of natural resources, the necessity to reduce emissions and discharges of pollutants into the air, the problem of the energy impact on global climate change and some others.

Taking into consideration the technical, natural, production and environmental factors, we determined the directions for ensuring the energy security of single-industry towns of the Republic of Kazakhstan (Table 5).

Table 5: Directions of ensuring energy security of single-industry towns by energy zones

Energy zones	Characteristics	The direction of ensuring energy security
North zone	1. Sufficient coal reserves 2. Application of backward technologies, machinery and equipment	1. To attract investments for renewal of fixed assets 2. Creation of active demand for energy sector services within the country 3. Application of alternative energy sources 4. Ensuring environmental safety of facility construction and operation 5. Application of advanced innovative technologies
Western zone	1. Significant reserves of oil and gas 2. Developed energy infrastructure	1. Reducing man-made disasters (oil spills, emissions of harmful components into the atmosphere) 2. Application of advanced innovative technologies 3. Use of alternative energy sources
South zone	1. Insufficient reserves of energy resources 2. High level of energy consumption	1. Diversification of resources supply 2. Introduction of innovations to reduce dependence on energy imports 3. Use of alternative energy sources 4. Enter into contracts with reliable energy suppliers 5. Implementation of energy conservation policy

Source: Developed by the authors

Although the single-industry towns of the Northern and Western zones are extremely rich in fossil fuel resources, renewable energy sources would provide an opportunity not only for economic and energy diversification, but also for the environment and human health enhancement.

Natural conditions in the Republic of Kazakhstan create opportunities for the development of generation based on wind, solar and water power energy. According to the Concept of the Development of the FEC of the Republic of Kazakhstan until 2030 (2014), the single-industry town has a great potential for using renewable energy sources:

- The hydro potential of medium and large rivers is 55 billion kWh, small rivers-7.6 billion kWh per year;
- The potential of solar energy is estimated at about 2.5 billion kWh per year, and the number of sunshine hours per year is estimated at 2200–3000 out of 8760;
- Wind potential reaches 1 820 billion kWh per year;
- The thermal potential of geothermal water is 4.3 GW, but their usage is more appropriate for heat supply purposes.

Thus, the aggregate potential of renewable energy sources for generation of electric power is 1 885 billion kWh, thermal potential-4.3 GW. Generation based on wind energy has the greatest potential.

The significant direction in ensuring the energy security of single-industry towns is the minimization of the techno genic impact of energy on the environment through the modernization of equipment and the new technology application.

At this juncture, it is advisable to use mechanisms of energy integration between single-industry towns, which will provide the opportunity for rapid response to man-made disasters.

As the directions of ensuring energy security of single-industry towns in energy zones demonstrate, saving energy resources is equivalent to their production, and often it is precisely a more environmentally responsible way of ensuring energy demand. Efforts to improve energy efficiency and energy saving are extremely conducive to the energy intensity reduction of economic development, thereby strengthening the energy security of single-industry towns.

5. CONCLUSIONS

The energy security of single-industry towns is the most critical component of the national security of the Republic of Kazakhstan. An important role in the production of electricity is conducted by power stations of single-industry towns, in which more than 50% of the country's electricity is produced. In the single-industry towns of the Republic of Kazakhstan, there are 5 power plants of national importance, which ensure the generation and sale of electricity to consumers in the wholesale electricity market.

Classification of single-industry towns by energy zones demonstrated that the Northern Zone is an energy-rich one, and the Southern and Western zones suffer a power shortage. The power stations of the single-industry towns of the Western zone are fully operating on gas, and the Northern Zone power plants use mostly cheap local coal. Single-industry towns of the Southern zone import coal, gas, fuel oil and electricity from other regions of Kazakhstan.

Worn out equipment and obsolete technologies are still applied in power stations of single-industry towns. The average lifespan of equipment in thermal power plants is 30.8 years, hydroelectric power stations-37.7 years. At the same time, 57% of the power plants' capacity has been in operation for more than 30 years.

The authors attribute technical, natural, production and environmental factors to the factors that have a significant impact on the energy security of single-industry towns. The authors also

identified the following main areas for ensuring energy security of single-industry towns: To attract investments for the renewal of fixed assets; to use alternative energy sources; to apply advanced innovative technologies; to reduce man-made disasters (oil spills, emissions of harmful components into the atmosphere); diversify supply of resources; implement energy conservation policies and others.

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