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Energy Security and Sustainability in Eurasian Economic Union in the Terms of Economic Growth: The Case of Kazakhstan’s Energy Sector up to 2040 Perspectives

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ABSTRACT

The economy of Kazakhstan is the first economy in Central Asia and the second among Eurasian Economic Union (EAEU) countries after Russia. On rates of hydrocarbon raw materials extraction Kazakhstan is included into first ten countries of the world. Kazakhstani economy is based on heavy industry, ferrous and non-ferrous metals, and oil and gas. And it allows Kazakhstan is being on the road of economic growth. With economic growth, the energy production and consumption are also increasing rapidly, resulting first of all, on harmful carbon emissions. Thus, the purpose of this research is to carry out a comparative assessment in the energy sector development and to submit forecast of its demand and its environmental impact in terms of Kazakhstani economic growth up to 2040. First scenario (base case) assumes conventional development pattern together with neither significant changes in the patterns of energy supply and demand nor extensively changed policies and measures. The second one (Mitigation) assumes a technological improvement, regulation and industrial development policies and additional policies which have been designed to promote energy efficiency and reduce emissions across the economy. The simulations are applied until the year 2040, while 2015 is set as the base year. The findings suggest in both scenarios Kazakhstan will continue to pursue its economic development driving energy demand and carbon emissions will also raise. However, under Mitigation Scenario, emission intensity will be lower insignificantly.

Keywords: Kazakhstan, Energy, Carbon Dioxide, Economic Growth
JEL Classifications: 0130, Q400, Q430

1. INTRODUCTION

Kazakhstan has significant oil and gas reserves and abundant mineral resources, including copper, lead, zinc, iron ore, manganese, titanium, chromium, and uranium (Karatayev and Clarke, 2014). This fact allows Kazakhstan has a stable national income and to be on a road of rapid growth in economy. The country ranks 53rd place in the world according to gross domestic product (GDP) (World Bank, 2019). However industrial sector is high energy intensive, due this fact, CO₂ emissions are on the rise in Kazakhstan (Aldayarov et al., 2017). As a consequence of this development Kazakhstan has become large CO₂ emitter in the world. The country ranks 25th place in the world according to carbon dioxide emissions (BP, 2018). In addition, process of industrialization and a lack of government attention to environment have resulted in large scale environment degradation. Among serious environmental problems are the shrinking of the Aral Sea and the steadily rising of water level of Caspian Sea (Valeyev et al., 2019), nuclear waste (Stawkowski, 2016), soil and water pollution (Karatayev et al., 2017; Medetov et al., 2018).
Climate change in Kazakhstan is another environmental concern. More than 60% of the whole Kazakhstani territory is subject to soil degradation, desertification, and water shortages, all of which would be exacerbated by climate change (Salnikov et al., 2015). Kazakhstan has already today suffered from climate change. Most likely that climate change reveals itself through: temperature increase; changeable nature of precipitation; aridity increase; and more frequent cases of extreme weather conditions. All this has been accompanied, in particular, by more frequent cases and intensity of floods, droughts, mud flows, glacier melting and mudslide. As a participant of Kyoto protocol and Paris agreement, Kazakhstan is under a pressure to reduce negative impact on environment and cut carbon emissions (Sabyr et al., 2019). Therefore, Kazakhstan has declared its acceptance of voluntary quantified commitments for the period of post-Kyoto and Paris Agreement - to reduce greenhouse gas emissions for 35% by 2040 compare to 1992 and by 40% at 2050 (Diyar et al., 2014; Bekturganova et al., 2019). The country has significant renewable energy potential including bioenergy potential, and bioenergy is viewed in national strategies as important tool for many sectors and mitigation perspectives as well as from the perspective of developmental goals such as energy security and rural development of Kazakhstan (Koshim et al., 2018). However, the current curvation of renewable energy sources is about 1% (Rivotti et al., 2019).

2. SCENARIOS METHODOLOGY

The study uses scenario-based modelling tool proposed by Cai et al. (2007) and Karatayev et al. (2019) to assess the CO2 emission mitigation potential of Kazakhstan’s energy sector. In order to collect data authors used primary and secondary sources, at a national level, like the National Energy Balance statistics, Ministry of Environmental protection, Ministry of oil and gas, Ministry of industry and energy, Kazakhstan Electricity Grid Company and the Kazakhstani national GHG inventory, made by the UNDP Kazakhstan, and at international level as well, like the World Bank annual statistics and International Energy Agency.

Additionally, in order to create scenarios authors have studied the long term strategic plans: Development programs of industries of RK up to 2015-2030; Development Program of Kazakhstan until 2030; The scheme of development and location of productive forces of the Republic of Kazakhstan for the period until 2050, which was developed in 2008 by the Economic Research Institute supported by the grant of Ministry of Economics and Budget Planning of RK; The Strategy of Industrial Innovation Development of Kazakhstan for 2010-2030, Ministry of Economics and Budget Planning; Energy Sector Development Program until 2040 (including Programme for the Development of the Electricity Sector up to 2040); National Concept on the Transition of Kazakhstan to Sustainable Development for 2015-2050; National Strategy Kazakhstan – 2050 (Bekturganova et al., 2019).

Based on these data authors developed two scenarios and these results were discussed and verified with local experts (e.g., Kazakhstan Institute of Strategic Research, Institute of Economic Research, Research Institute of Geography, Ministry of Economics and Budget Planning, Local government representatives in sphere of Environmental protection from Aktau, Atyrau, East-Kazakhstan and North Kazakhstan provinces).

3. DEMOGRAPHIC TRENDS

In 2015 the population of Kazakhstan was 16.8 million. Population density was 5.7 people per square meter, which was one of the lowest in the world. According to our projections to 2040 the population of 16 million in 2015 is expected to increase to 22.4 million by 2030 (Sayimova et al., 2017). The result of population projection is presented below in Table 1 “Expected demographic trends.”

4. ECONOMIC GROWTH

Since 2001, GDP growth has been among the highest in the world. In 2008 the global financial crisis took a significant toll on Kazakhstan’s economy, it has rebounded well. Rising commodity prices have helped revive Kazakhstan’s economy, which registered roughly 4-5% growth in 2015-2018. This link and dependency on oil exports will remain the same as long as the Kazakhstani industry and economy does not develop in other areas, like agriculture and manufacture, mid or high technology and service-oriented sector among others and the development of these sectors will take time (Saiymova et al., 2018; Saparaliyev et al., 2019a). Based on this assumption, for the long term the research assumed that the Kazakhstani GDP growth rate will remain linked to world prices for oils and gas, metals and cool, while for the long term (between 2015 and 2040).

Comparing the export concentration index of the Eurasian Economic Union (EAEU) countries, Kazakhstan and Russia show the highest values of this indicator – 0.651 and 0.377, respectively, and in Belarus and Armenia - respectively 0.248 and 0.215, which brings them closer to the average for developing countries (0.130), however, significantly exceeding it, not to mention the value for developed countries (0.065). High indicators of export concentration, especially in Russia and Kazakhstan, indicate a low level of diversification of their economies in general, as well as low competitiveness of non-primary products in the world market (World Bank, 2019). Differences in the concentration index of the export of EAEU countries constitute the basis for the influence of external factors on their economies, the spread of the economic crisis, primarily in Russia and Kazakhstan as oil-exporting countries, through a fall in export earnings, as well as a decrease in access to external financing schemes.

According to the projected data (Table 2) - active carrying out of an industrial policy will provide economy growth rates not less than on 7.8-8.5% in a year. It will allow to increase by 2040 in comparison with 2010 gross national product volume approximately at 3.5-3.8 time, to lead mid-annual increase rates in manufacturing industry to 8-8.4%, to rise labor productivity growth by 2040 in comparison with 2015 not less than in 3 times. Dynamical GDP growth per capita which is predicted by 2015 at a rate of 678.9 thousand tenge will proceed that on 27.7% exceeds level of 2015, in 2040 this indicator will make 8.5 times. On the basis of it the further growth of monthly average incomes of the population will be provided. Manufacture goods growth in gross national product occurs, first of all, at the expense of increase in volumes of the added
As it was described earlier, Kazakhstan is very rich by mineral resources (Karataiev et al., 2016). Stocks of coal make 30-35 billion tons (BP, 2018). Kazakhstan possesses 3.6% of world reserves of the coal, about 910 billion tons (Table 3).

Oil resources of Kazakhstan are the biggest among the former Soviet republics. Independent experts of the Kazenergy Association. (2017) estimated the confirmed stocks in 39 billion barrels. The previous estimates are given by lower figures: 6.42 billion barrels it agrees with OPEC and 8 billion barrels agree BP (BP, 2018). Recently Kazakhstan finished a new assessment of the oil stocks and estimated the confirmed and possible oil stocks about 35 billion barrels. Considering rich mineral, the Government of Kazakhstan plans to increase considerably level of oil, gas, and coal and uranium production (Table 4).

It is necessary to pay attention to that fact that the current outputs of coal in Kazakhstan exceed demand in the republic (Abdukarimova et al., 2018; Lobova et al., 2019). Export makes 1/3 from the general production of coal. Among CIS countries, the biggest consumer is Russia (63.5% from the general consumption of coal).

5. ENERGY SECTOR

Cost in the industry. A considerable impact will render the volume increasing in export of oil and improvement of the structure of exported goods towards extension share of finished goods on a share size of pure goods export and services in GDP (Saparaliyev et al., 2019b). It is supposed that export will keep high dependence on term of a fuel and energy complex. Almost half of that is made in the country, is exported, and more than half which is consumed in the country, imported. These are typical macroeconomic proportions of underdeveloped country with raw economy orientation.
After Russia on volume coal consumption there is Ukraine (22.1%) and then Kazakhstan (13.7%). Identical tendency characteristics for oil and gas sector also slightly involved in obtaining energy. More than 80% of the republic oil productions send for export (International Energy Agency, 2017).

At the same time, coal is remaining and will be remain main resources for energy production. For these purposes, Ministry of Industry and new technologies developed the concept of development on the coal industry up to 2030. According to the concept the increase in volume of coal mining from 96.3 million tons in 2006 to 145.6 million tons to 2020 is presupposed (Table 5).

The energy generation is distributed by the type of power plant in a following way: thermal power plants – 87.7%, hydroelectric power stations – 12.3%. Coal is the main source for receiving the electric power in Kazakhstan, and nearly 73% of the electric power are made at coal power plants, 12.3% - from water resources, 10.6% - from gas and 4.9% - from oil (National Energy Report, 2017).

As it was already noted in many references (Karatayev and Clarke, 2014; Rivotti z., 2019), the industry is the biggest consumer of energy. It absorbs a half of final consumption while housing and economic and serving sector consumes about 40%, and transport sector only 10%. It should be noted that such high share of electricity consumption is closely connected with an environment production of the country in such branches, as ferrous and nonferrous metallurgy, the chemical industry, the industry of building materials and so on which usually are considered as the most power-intensive. It should be noted that in sector of the electric power of the industry the main development is the share of coal. Coal is also widely used as a power source and for domestic needs.

The renewable energy resource potential in Kazakhstan is significant but was largely neglected (Karatayev and Clarke, 2016; UNEP and Bloomberg, 2017). The share of renewables is only 1.1% in total primary energy supply. A hydro power capacity of 2000 MW is installed. Most of the hydro stations currently in operation require reconstruction and modernization due to large exploitation period (most of hydro station were in operation for 40-55 years) and depletion of equipment (Teluyev, 2017). However the potential capacity is estimated to be 10 times higher, i.e., 27 billion kWh/year. Mini-hydro (units of <10 MW), has a significant potential. Based on existing studies, there are at least 453 potential small hydroelectric power projects with 1380 MW of total installed capacity and 6.3 TWh of mean annual production. Kazakhstan has very strong wind potential, largely due to the pervasiveness of wind-intensive areas. The majority of the country’s land mass has wind potential of at least 4-5 m/s, with a few coastal areas reaching 6 m/s. The estimated potential amounts to 1.300 TWh. The sheer size of Kazakhstan compared to its Central Asian neighbors gives it a distinct advantage in the development of solar power, since more surface area yields more direct sunlight. The country receives between 2200 and 3000 h of sunlight per year on average. This allows using of the sun batteries, in particular portable photovoltaic applications in the rural area on the cattle farms.

According to our projection, perspective levels of electric power production as a whole on the republic were predicted in volume of 110 MTOE by 2040, with a gain for 1.8-2.4%. Agreeing to national long-term programs, development building of new power objects, restoration, capital and maintenance, modernization of power generation facilities, including reconstruction of electric networks and substations is provided. It is supposed that construction input of small hydro-stations and input of wind power stations, which construction to be carried out to 2015-2025. However according our projected scenarios, considering technological capabilities of Kazakhstan, energy will remain to depend on coal and its share in power consumption will grow only. The use of natural gas also will grow up respectively, and also too insignificant growth will be observed at the expense of alternative sources using.

6. EMISSIONS AND TRENDS

According to the world development indicators, the total CO₂ emissions were estimated at 261.3 mln. tons in the year 1992. The economic collapse in Kazakhstan from 1990 up to 2000 has resulted in the consequent decline of the energy consumption and the corresponding CO₂ emissions (USAID, 2018). In 2000, the overall CO₂ emission constituted 140.8 mln. tons, or 53% less than the level in 1992. Due to the high energy intensity of the economy and the prevailing use of coal in energy production, it was expected, however, that the recovery of the economy has resulted in rapid increase of CO₂ emissions. Despite the remaining growth of CO₂ emissions from 2000, total CO₂ emissions in 2015 remain below 1992-year level (203 mln. tons of CO₂). However Kazakhstan has globally position as the largest emitter of greenhouse gases in post-Soviet countries. Also, Kazakhstan belongs to the countries with the highest CO₂ emissions per capita.

In accordance to a share in total CO₂ emissions energy sector emissions prevail – in 1990 and 2015 their share came to 83% and 87% correspondingly. Agricultural sector is on the second place of share, which contribution slightly reduced from 11% in 1990 to 8.08% in 2015, and share of CO₂ emissions from the other category during the concerned period has been in the limits of 1.6-2.13% correspondingly. As mentioned before coal is the main resource for energy sector Kazakhstan. Thus, coal used by Kazakhstan gave off an estimated 155 and 124 million metric tons of CO₂ in 1992 and 2015. In 2015, 73% of CO₂ emissions from fuel combustion were produced from coal.
7. SCENARIOS DEVELOPMENT

7.1. Base Case Scenario
This scenario assumes the future economic development along the conventional path. New policies are put in place to encourage energy efficiency, renewable energy, or other emissions abatement but limited actions due to number of different barriers. This means neither significant changes in the patterns of energy supply and demand nor extensively changed policies and measures. In principle it is prolongation of perceivable trends. In such a scenario global demand for energy resources would remain fairly strong in the post-crisis recovery stage. High earnings from exports of oil and gas are capable of maintaining the Kazakhstani economy as a whole. It is therefore possible that neither the state nor big business will implement a serious reduction CO₂ emissions policy. This could lead to: Kazakhstani energy efficiency remaining less than half that of developed countries; Slower progress towards energy efficiency in Kazakhstan during the coming decade and increased export of energy-intensive commodities with low levels of processing (metals, other resources materials etc.); Continued dominance of coal as the feedstock to fuel-fired power stations; Continued low levels of oil product export (3-5 times less than exports of crude oil by volume); Government energy priorities remain focused on increase of oil and gas industry.

The transition to a low-carbon economy is a priority for Kazakhstan, as outlined in the Kazakhstan-2050 strategy (Karatayev and Hall, 2017). The main ways to achieve the goal are energy efficiency, energy saving, transition to alternative and renewable forms of energy. By 2030, it is planned to reduce the energy intensity of GDP by 25%. Currently, the specific energy consumption per unit of GDP is 1.9, i.e., is one of the highest in the world. However, country faces a number of barriers in policy implementation. The high energy intensity of the economy is one of the negative factors for its development, due to the fact that it reduces the competitiveness of manufactured goods and pollutes the environment to a great extent. According to the projected data of the Base case scenario, CO₂ emissions could increase from 203 MtCO₂ in 2015 to 253 in 2025, 359 in 2030, and 435 in 2040 (Table 6). The threshold of 261 MtCO₂ 1992 will be reached in 2025. Emissions increases due to the fact that raises the total national consumption of energy without changes in use as a primary resource – coal. The share of coal in total energy consumption will only increase.

7.2. Mitigation Scenario
Which incorporates a range of additional policies designed reduces emissions across the economy; improve energy and electricity efficiency and development of a renewable electricity programme and instruments to support it. Good institutional environment is created for development of other economic sectors (in addition to the fuel and energy sector). These factors in combination could have the following consequences: Shift of government and private investments from extensive development of the fuel and energy sector to its modernization. Achievement of greater refining depth and increase of oil product export volumes towards the level of crude oil exports; Energy efficiency innovations and much greater use of existing mechanisms for energy saving; Targeting of competitive advantages in new energy (alternative energies); Government energy policy becomes focused on competitiveness of other industries and investments into fixed capital in metallurgy and chemical branch, in mining, in mechanical engineering, in fuel and energy complex.

According to the Mitigation scenario, CO₂ emissions could increase from 203 MtCO₂ in 2015 to 200 in 2025, 251 in 2030, and 361 in 2040. The threshold of 261 MtCO₂ 1992 will be achieved in 2030 (Table 7), despite the insignificant measures taken from

### Table 6: Forecasting summary emissions CO₂ from energy sector (base case scenario, MtCO₂)

| Year | Total CO₂ | Energy sector |
|------|-----------|---------------|
| 2015 | 202546.5  | 180094.6      |
| 2020 | 196208.0  | 170966.7      |
| 2021 | 203400.7  | 170924.6      |
| 2022 | 208470.1  | 171799.6      |
| 2023 | 225813.0  | 189941.1      |
| 2024 | 234110.5  | 205217.2      |
| 2025 | 252875.2  | 222001.4      |
| 2026 | 272210.3  | 236823.0      |
| 2027 | 290905.8  | 258902.6      |
| 2028 | 310977.7  | 286790.0      |
| 2029 | 332233.1  | 299009.8      |
| 2030 | 359854.9  | 318767.6      |
| 2031 | 365488.7  | 330795.2      |
| 2032 | 378133.1  | 349875.8      |
| 2033 | 386000.4  | 344896.3      |
| 2034 | 387951.2  | 353517.5      |
| 2035 | 393461.7  | 370463.0      |
| 2036 | 410188.0  | 378659.8      |
| 2037 | 415970.1  | 396997.9      |
| 2038 | 42628.1   | 42628.1       |
| 2039 | 310977.7  | 286790.0      |
| 2040 | 332233.1  | 299009.8      |

### Table 7: Forecasting summary emissions CO₂ from energy sector (Mitigation scenario, MtCO₂)

| Year | Total CO₂ | Energy sector | Coal | Oil | Gas |
|------|-----------|---------------|------|-----|-----|
| 2015 | 202546.5  | 180094.6      | 117740.2 | 33839.9 | 28965.4 |
| 2020 | 196208.0  | 170966.7      | 121939.0 | 32470.0 | 16580.7 |
| 2021 | 203400.7  | 170924.6      | 122447.2 | 31486.4 | 16991.0 |
| 2022 | 208470.1  | 171799.6      | 127583.7 | 31895.9 | 17720.0 |
| 2023 | 225813.0  | 189941.1      | 130519.9 | 34549.4 | 23871.7 |
| 2024 | 234110.5  | 205217.2      | 144212.1 | 37038.1 | 23922.1 |
| 2025 | 252875.2  | 222001.4      | 158401.0 | 39603.0 | 24000.1 |
| 2026 | 272210.3  | 236823.0      | 165776.1 | 42628.1 | 28418.8 |
| 2027 | 290905.8  | 258902.6      | 181234.3 | 46603.1 | 31068.7 |
| 2028 | 310977.7  | 286790.0      | 199274.5 | 49818.6 | 37677.0 |
| 2029 | 332233.1  | 299009.8      | 203326.7 | 53821.8 | 41861.4 |
| 2030 | 359854.9  | 318767.6      | 217172.4 | 55075.8 | 43646.4 |
| 2031 | 365488.7  | 330795.2      | 228941.2 | 57235.5 | 44797.5 |
| 2032 | 378133.1  | 349875.8      | 240152.3 | 59215.6 | 49607.8 |
| 2033 | 386000.4  | 344896.3      | 234226.4 | 59381.3 | 51288.6 |
| 2034 | 387951.2  | 353517.5      | 239637.5 | 60753.2 | 53126.9 |
| 2035 | 393461.7  | 370463.0      | 252759.8 | 62324.3 | 55162.2 |
| 2036 | 410188.0  | 378659.8      | 258008.3 | 62758.8 | 57992.8 |
| 2037 | 415970.1  | 388734.3      | 264723.4 | 64392.2 | 59618.7 |
| 2038 | 421697.3  | 403876.7      | 275157.5 | 66037.8 | 62681.4 |
| 2039 | 429193.0  | 407689.2      | 275713.6 | 67894.2 | 63992.1 |
| 2040 | 435741.2  | 425809.7      | 290857.3 | 69805.7 | 65146.7 |
the Mitigation Scenario aiming to improving energy efficiency, energy technology and service sector. However, with the projected continued growth across emissions-intensive sectors, emissions are on an upward trajectory even in this scenario.

Choice of fuel in the power sector is a major determinant of future emissions trajectory in Kazakhstan, because the power and heat sector based on coal already accounts for a very significant proportion of emissions. Kazakhstan’s reliance on coal across most sectors results in a significant increase in emissions over time. Limiting the use of coal would therefore substantially reduce emissions. For such a scenario to be feasible, however, the government would need to significantly increase its efforts to modernize power plant and industry sector which required additional significant investments.

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8. CONCLUSION

The results imply that energy demand and associated CO₂ emissions in Kazakhstan will rise in both scenarios in terms of the economic growth until 2040. According to the international obligations of Kazakhstan must reduce emissions at 35% by 2040 compare to 1992 and by 40% at 2050. In this case, our analysis suggests that Kazakhstan can meet the 2040 target with the state level and national projects. All the long-term national projects are aiming to economic growth and exploitation of natural resources. In addition, oil and gas and energy sector of the country claim to increase capacity and performance. Therefore, even under Mitigation scenario CO₂ emissions will rise.

In 2040, the model results estimate that both scenarios show that based on primary energy demand by energy sources, total CO₂ emissions are projected to increase. The resulting Base Case Scenario emissions nonetheless will be substantially higher than current levels, and significantly higher than Kazakhstan’s voluntary target of 15% reduction relative to 1992 levels in the period to 2040 (Figure 1). However, under the Mitigation Scenario, environmental pressures from energy production and consumption are also likely to mitigate insignificantly. Under Mitigation Scenario target 2040 reduction CO₂ emissions by 35% perhaps would be achievable with significant efforts (Figure 2).
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