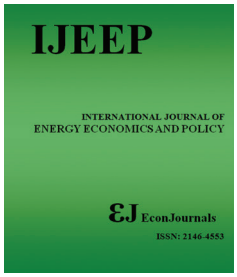

International Journal of Energy Economics and Policy

ISSN: 2146-4553

available at http: www.econjournals.com

International Journal of Energy Economics and Policy, 2020, 10(5), 447-453.

Energy Intensity of Kazakhstan's GDP: Factors for its Decrease in a Resource-export Developing Economy

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Received: 22 April 2020 **Accepted:** 10 July 2020 **DOI:** https://doi.org/10.32479/ijeep.9817

ABSTRACT

Kazakhstan continues to use several times more energy per production unit than more developed countries and regions of the world. This study is the first comprehensive review and analysis of energy intensity factors of Kazakhstan's gross domestic product for the priod of 1990-2018. We have studied the influence of various factors on the GDP energy intensity: Indicators characterizing the country's economic growth, power industry and living standards development. Calculations made have shown that the most significant influence on improving the energy efficiency of the economy is exerted by the indicators of Net Energy Imports and GDP per capita at PPP. The calculated elasticity coefficient shows that with an increase in the value of Net Energy Imports by 1%, the expected decrease in energy intensity shall be 0.85%. With an increase in GDP per capita of 1%, the expected decrease in energy intensity shall be 0.44%. However, in Kazakhstan, the influence of GDP per capita is mediated by the export of energy resources, which is confirmed by the high correlation between GDP growth, total energy production and export. We are concluding that for the developing economy of Kazakhstan exporting energy resources, the conversion of primary energy into products with high added value is more rational for economic development and energy conservation.

Keywords: Energy Resources, Energy Intensity, Energy and Growth, Energy Policy, Kazakhstan
JEL Classifications: O13, Q43, Q48

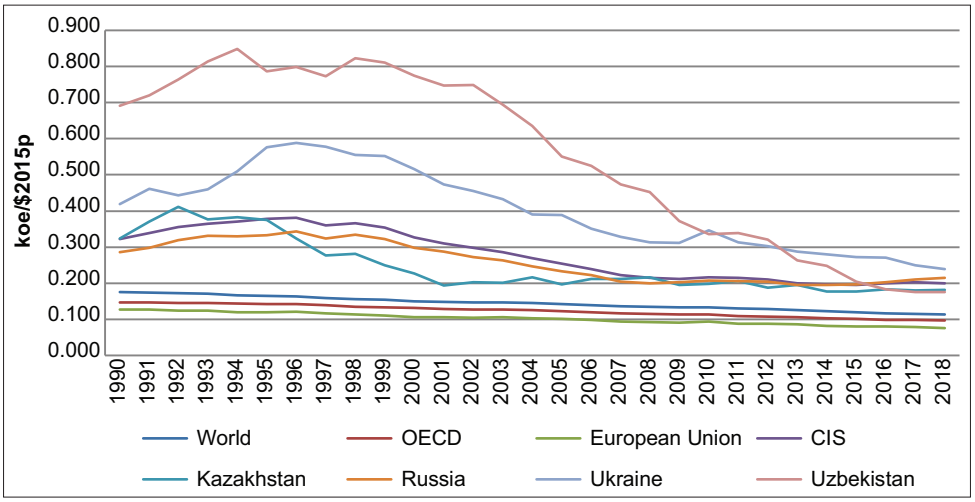
1. INTRODUCTION

Traditionally, the economies of the CIS countries are considered very energy intensive. The GDP energy intensity has decreased during the transition period, but progress wasn't even, and most countries with economies in transition continue to use several times more energy per production unit than in other, more developed countries and regions of the world (Figure 1).

Based on the analysis of the information presented in Figure 1, we conclude that the CIS countries, including Russia, Ukraine, Uzbekistan and Kazakhstan, have the highest GDP energy intensity. At the same time, it is noteworthy that common reasons for all these countries that influenced their current situation for a possible comparison can not include their traditionally considered geographical location, size of the occupied territories, climatic features and other fairly obvious characteristics.

In this regard, we can assume that GDP energy intensity in each country is formed under the influence of various factors that determine the features of their functioning at a certain stage of their development. However, in any case, their influence manifests either through a change in the level of energy consumption in each country, or through a change in the volume of their gross product. All of this fully applies to the functioning conditions of each country, including Kazakhstan.

Figure 1: GDP energy intensity at constant purchasing power parities (koe/$2015p)



Source: Enerdata

This study is the first comprehensive review and analysis of energy intensity factors of Kazakhstan's gross domestic product for the period of 1990-2018. We study the influence of various factors on the GDP energy intensity: indicators characterizing the country's economic growth, development of power industry and the state of employment and living standards of the population.

2. LITERATURE REVIEW

Improving energy efficiency is one of the most important development tasks for almost all countries of the world. The relevance of its solution is due to the non-renewable energy resources limit and the need to ensure the competitive advantages of national manufacturers based on the most efficient use of energy resources. We use various indicators to assess energy efficiency, including the energy intensity of gross domestic product (GDP) – the ratio of economic growth rates to energy consumption growth rates.

To fully understand the factors that can affect the numerical expression of the GDP energy intensity of a developing economy exporting natural resources, we shall conduct a detailed review of the literature on the study subject.

The paper "China's regional disparities in energy consumption: an input-output analysis" (Li et al., 2014) divides the regions of China into 4 groups according to the GDP energy intensity. According to researchers, highly developed regions of China with low GDP energy intensity (e.g., Shanghai), need to be focusing energy conservation on promoting a low-energy lifestyle. For less developed regions of China with low energy intensity (e.g., Guangxi), economic development is more relevant than energy conservation. For developing and energy-absorbing regions of China, improving energy efficiency in industry is of great importance. For developing regions and regions exporting energy, the conversion of primary energy into products with high added value is more rational for economic development and energy saving (Li et al., 2014).

The analysis performed for a paper by Deichmann et al. (2018) and based on a panel data set of 137 countries in the period of 1990-2014 has revealed the effect of population income growth on the change in GDP energy intensity. In their study, the GDP energy intensity correlates with population income growth negatively. So, if the level of income per capita reaches $5,000, the rate of decrease in energy intensity slows down significantly, by more than 30%. The results of their research show that when countries go beyond the population's lower-middle-income levels energy efficiency policies become much more important to maintain the pace of energy efficiency.

Cornillie and Fankhauser (2004) explore the energy intensity of transition economies. The authors conclude that energy prices and the progress of entity restructuring are important factors for more efficient use of energy.

Dargahi and Khameneh (2019) identify price and non-price determinants of Iran's energy intensity. Their study reveales that the elasticity of the energy intensity of Iran's GDP in relation to overall productivity, real energy prices and industrial development is negative. Income per capita has a positive linear relationship with the energy intensity of the economy.

A paper by Pan et al. (2019) notes that industrialization has a direct positive effect on GDP energy intensity, and trade openness has a direct negative effect. Industrialization and trade openness have an indirect negative effect on the GDP energy intensity through technological innovation and economic growth, respectively. In the case of individual impacts, only industrialization positively affects the GDP energy intensity, while trade openness, economic growth and technological innovation affect it negatively (Pan et al., 2019).

Chepel (2017) examines the GDP energy intensity in the CIS countries. He concludes that the CIS countries are highly potential to improve energy efficiency. This requires augmenting the capacity of state institutions and focusing on developing competitive energy markets, introducing energy audits, limiting the shadow economy and fighting corruption more intensively.

The paper by Semin et al. (2019) concludes that the main factors of a high level of Russia's energy intensity are the territory size, climatic conditions and the energy-consuming structure of industry. The authors conclude that in the absence of structural changes in the economy, optimizing the structure of electricity generation is an effective way to reduce the energy intensity of the Russian economy. In their opinion, optimization of the structure of electricity production shall ensure a reduction in operating costs for electricity production. This, in their opinion, shall reduce the consumption of gas and coal at thermal power plants (Semin et al., 2019).

A Khasaev and Tsybatov (2018) study finds that economic growth is the most important condition for reducing Russia's GRP energy intensity: the higher economic growth, the greater its contribution to reducing GRP energy intensity.

The energy intensity of Kazakhstan's GDP is studied in a number of scientific papers.

A multitude of academic studies (Kerimray et al., 2017; Smagulova et al., 2017) claim that high energy intensity of Kazakhstan economy leads to irrational use of fuel and power resources.

Gómez et al. (2014) have identified the main causes of energy inefficiency in Kazakhstan: excessive and irrational energy consumption in the household and services, industrial sector inefficiency, high depreciation of fixed assets in the power generation sector.

The paper by Kerimray et al. (2015) suggests reasons for the power system inefficiency and the high energy intensity of Kazakhstan's GDP: Administrative, economic, geographical and technical factors contribute to the GDP high energy intensity.

Smagulova et al. (2017) argue that the natural resource extraction sector plays the most important role in the observed change in GDP energy intensity. In their opinion, the share of this sector in the total GDP has increased, which led to an increase in energy intensity due to inter-industry structural effects.

Kazmaganbetova et al. (2016) analyzes the influence of the sectoral structure on energy use and economy energy efficiency by region. The main conclusion made is that the energy intensity of Kazakhstan's regional economies decreases with an increase in GRP per capita.

A number of studies link the GDP energy intensity to environmental issues in Kazakhstan (Li et al., 2018), development of renewable energy sources (Karatayev et al., 2016), and the impact of ICT and trade openness (Tleppayev, 2019).

The analysis of scientific literature allows us to formulate the following number of hypotheses:

- Hypothesis 1. Kazakhstan's GDP energy intensity forms under the influence of factors determining the features of the national economy functioning
- Hypothesis 2. The energy intensity of Kazakhstan economy decreases with an increase in GDP per capita at PPP
- Hypothesis 3. The production and export of energy resources play the most important role in the observed change in the energy intensity of Kazakhstan's GDP
- Hypothesis 4. The conversion of primary energy to high value-added products is more rational for economic development and energy conservation in Kazakhstan.

3. DATA SOURCES AND METHODS

We have analyzed 24 indicators reflecting the influence of various factors on the energy intensity of Kazakhstan economy. We used statistical information of the World Bank and Enerdata's World Energy Statistics for the period from 1990 to 2018. For the analysis purposes, we have combined all indicators into three groups (Table 1).

The first group includes indicators reflecting the influence of economic growth factors. The second group includes indicators characterizing power sector development. The third group consists of indicators characterizing employment and living standards in the country.

In accordance with the identified hypotheses for understanding the factors that determine the energy intensity of the Kazakhstan economy, we propose an empirical model:

$$Energy\_intens = \alpha Econ\_growth + \beta Energy + \gamma Emp\_livstand + \varepsilon, \quad (1)$$

where:
Energy_intens is GDP energy intensity at constant PPP, koe/$2015p
Econ_ growth are indicators reflecting the impact of economic growth factors
Energy are indicators characterizing power sector development
Emp_livstand are indicators of employment and living standards in the country.

4. RESULTS AND DISCUSSION

For the multicollinearity check purposes, Table 2 presents data on the coefficients of pair correlations between variables.

Figure 2 shows scatter plots to understand the direction and type of relationship between the dependent variable and the main factors.

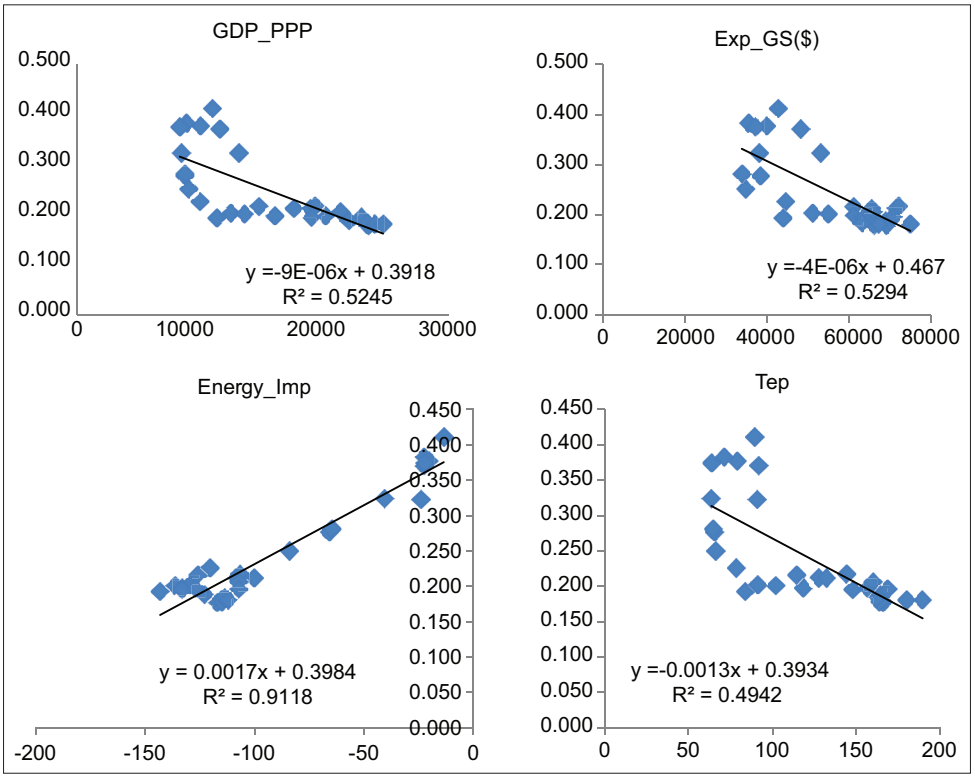
As a result of calculations, we have found that the energy intensity of Kazakhstan's GDP has a very high correlation dependence (>0.9) with the net energy import. Net energy Imports are calculated by deducing energy produced from energy consumption, which is measured in oil equivalent. Energy consumption relates to primary energy before being converted to other end-use fuels. A negative value of the net energy import indicator suggests that the country in question is a net exporter.

The correlation matrix (Table 2) and scatter plots (Figure 2) show that the energy intensity of the Kazakhstan economy has a strong correlation (>70) with a number of indicators, including

Table 1: Model variables

Variable	Reference	Indicator	Measure unit	Source
Economic growth (Econ_ growth)	GDP	GDP (constant 2010)	million US$	World Bank
	GDP_PPP	GDP per capita, PPP (constant 2011)	US$	World Bank
	Invest	Foreign direct investment, net inflows	million US$	World Bank
	Inf	Inflation, consumer prices (annual)	%	World Bank
	Imp_GS(%)	Imports of goods and services	% of GDP	World Bank
	Imp_GS($)	Imports of goods and services (constant 2010)	million US$	World Bank
	Exp_GS(%)	Exports of goods and services	% of GDP	World Bank
	Exp_GS($)	Exports of goods and services (constant 2010)	million US$	World Bank
	Ext_balGS	External balance on goods and services	million US$	World Bank
	R&D (%)	Research and development expenditure	% of GDP	World Bank
	Res_R&D	Researchers in R&D	per million people	World Bank
	R&D($)	Research and development expenditure	million US$	World Bank
Energy	Tep	Total energy production	Mtoe	Enerdata
	Edc	Electricity domestic consumption	TWh	Enerdata
	EP	Electricity production	TWh	Enerdata
	Renew	Share of renewables in electricity production	%	Enerdata
	CO_2	CO_2 emissions from fuel combustion	MtCO2	Enerdata
	Energy_Imp	Energy imports, net	% of energy use	Enerdata
	Epc	Electric power consumption	kWh per capita	Enerdata
Employment and living standards (Emp_livstand)	Popul	Population, total	million people	World Bank
	Emp_Agro	Employment in agriculture	% of total employment	World Bank
	Emp_Ind	Employment in industry	% of total employment	World Bank
	Emp_Ser	Employment in services	% of total employment	World Bank
	Life_exp	Life expectancy at birth, total	years	World Bank

Figure 2: Scatter plots between independent and dependent variables



Researchers in R&D, GDP per capita PPP, Exports of goods and services, Total energy production. Kazakhstan's GDP energy intensity shows a moderate and weak correlation with other indicators.

Also, the correlation matrix and scatter plots show that total energy production in Kazakhstan has a very high correlation dependence (>0.99) with GDP and GDP per capita at PPP. This indicates the large role of the power sector in Kazakhstan economy, and accordingly, its dependence on the energy resources price.

Further study of the degree of their influence on the GDP energy intensity required an analysis of a possible multicollinear dependence. Based on its results and the final indicator selection, a we have obtained a model for the influence of various indicators

Table 2: Correlation matrix

	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]	[11]	[12]	[13]	[14]	[15]	[16]	[17]	[18]	[19]	[20]	[21]	[22]	[23]	[24]	[25]
[1] Energy_Int	1,00																								
[2] GDP	–0,67	1,00																							
[3] GDP_PPP	–0,72	0,99	1,00																						
[4] Invest	–0,52	0,61	0,67	1,00																					
[5] Inf	0,62	–0,26	–0,29	–0,25	1,00																				
[6] Imp_GS(%)	0,64	–0,70	–0,69	–0,46	0,29	1,00																			
[7] Imp_GS($)	0,00	0,51	0,49	0,54	–0,08	–0,34	1,00																		
[8] Exp_GS(%)	0,13	–0,22	–0,16	0,01	–0,16	0,71	0,03	1,00																	
[9] Exp_GS($)	–0,73	0,89	0,94	0,69	–0,35	–0,55	0,50	0,07	1,00																
[10] Ext_balGS	–0,52	0,75	0,77	0,62	–0,22	–0,62	0,62	0,01	0,75	1,00															
[11] R&D(%)	0,48	–0,72	–0,67	–0,28	0,15	0,72	–0,63	0,39	–0,43	–0,56	1,00														
[12] Res_R&D	–0,81	0,86	0,89	–0,45	–0,32	–0,68	0,83	–0,76	0,13	–0,05	–0,53	1,00													
[13] R&D($)	–0,59	0,84	0,87	0,67	–0,19	–0,74	0,87	–0,17	0,83	0,84	–0,49	0,36	1,00												
[14] Tep	–0,70	0,99	0,99	0,65	–0,28	–0,66	0,47	–0,12	0,94	0,79	–0,67	0,67	0,87	1,00											
[15] Edc	0,21	0,50	0,45	0,30	0,07	–0,22	0,87	–0,03	0,37	0,52	–0,74	0,77	0,86	0,46	1,00										
[16] EP	–0,31	0,90	0,85	0,43	–0,11	–0,55	0,71	–0,24	0,72	0,63	–0,72	0,85	0,79	0,85	0,79	1,00									
[17] Renew	–0,07	–0,32	–0,34	–0,59	0,25	0,17	–0,54	–0,10	–0,33	–0,49	0,16	0,07	–0,77	–0,33	–0,56	–0,39	1,00								
[18] CO2	0,00	0,71	0,68	0,51	0,04	–0,35	0,79	–0,02	0,60	0,67	–0,68	0,64	0,91	0,69	0,92	0,89	–0,63	1,00							
[19]Energy_Imp	0,95	–0,51	–0,58	–0,44	0,54	0,43	0,16	–0,06	–0,63	–0,40	0,02	0,12	–0,14	–0,58	0,35	–0,14	–0,15	0,14	1,00						
[20] Epc	0,13	0,63	0,57	0,55	0,06	–0,16	0,88	0,24	0,53	0,69	–0,51	0,94	0,97	0,58	0,95	0,94	–0,86	0,95	0,22	1,00					
[21] Popul	–0,15	0,80	0,72	0,30	0,03	–0,55	0,61	–0,40	0,51	0,52	–0,79	0,80	0,70	0,72	0,78	0,95	–0,32	0,84	0,04	0,86	1,00				
[22] Emp_Agro	0,65	–0,96	–0,92	–0,48	0,23	0,75	–0,61	0,39	–0,76	–0,61	0,77	–0,78	–0,67	–0,91	–0,50	–0,88	0,16	–0,63	0,48	–0,56	–0,83	1,00			
[23] Emp_Ind	–0,69	0,98	0,98	0,60	–0,25	–0,72	0,68	–0,27	0,88	0,68	–0,70	0,79	0,79	0,96	0,50	0,88	–0,27	0,68	–0,52	0,59	0,78	–0,97	1,00		
[24] Emp_Ser	–0,63	0,93	0,89	0,43	–0,23	–0,74	0,59	–0,43	0,71	0,57	–0,78	0,77	0,63	0,88	0,49	0,87	–0,13	0,60	–0,46	0,53	0,84	–1,00	0,95	1,00	
[25] Life_exp	–0,42	0,91	0,85	0,56	–0,16	–0,57	0,63	–0,26	0,67	0–,58	–0,77	0,85	0,74	0,84	0,68	0,95	–0,62	0,77	–0,27	0,82	0,91	–0,92	0,87	0,92	1,00

on the energy intensity of Kazakhstan's GDP, which includes GDP per capita at PPP and Net Energy Imports:

$$Energy\_intens = 0,425 - 0,0000033GDP\_PPP + 0,00141Energy\_Imp \quad (2)$$

The determination coefficient $R^2 = 0.9544$ shows that the variation of the resulting indicator (*Energy_intens*) by 95.44% is explained by the dependence on factor attributes *GDP_PPP* and *Energy_Imp*. Statistical significance of the resulting equation is confirmed by the Fisher criterion F = 272.2, the value of which is higher than critical ($F_{crit} = 2.05$).

We feel fit to note that the obtained model includes indicators from the first two groups in question: from the group of indicators reflecting the influence of economic growth factors, and from the group of indicators characterizing the state of country's power sector. Unfortunately, indicators characterizing the qualiy of life weakly correlate with the energy intensity of Kazakhstan economy.

As it follows from the result analysis, the most powerful influence on the energy intensity of Kazakhstan's GDP is exerted by factors characterizing the state of conutry's power industry. They are manifested primarily through a change in Net Energy Imports (Figure 3).

The calculated elasticity coefficient shows that with an increase of the net energy imports value by 1%, the expected energy intensity decrease shall be 0.85%. Results determine the priority areas of economic development, which can lead to real changes in its energy efficiency.

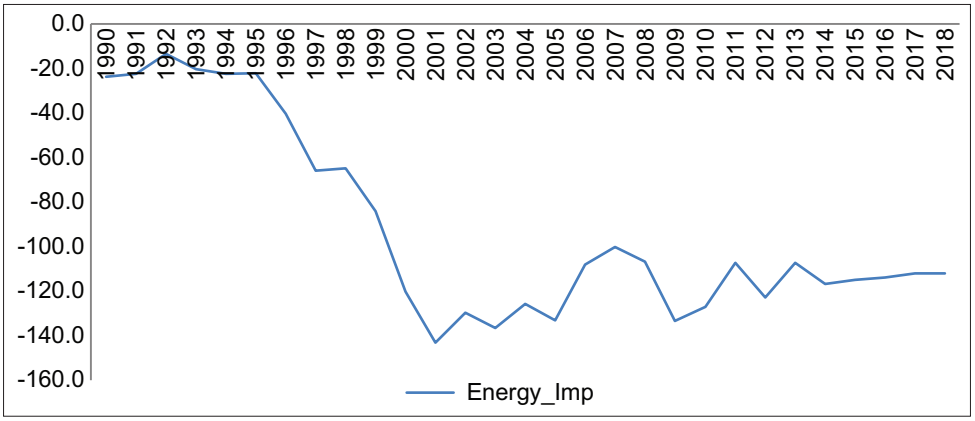
Figure 3 shows that Kazakhstan is a net exporter of power. Oil and gas sector appears to be the key sector of Kazakhstan's economy. It directly accounts for about 15% of GDP, more than half of the export of energy resources and more than 40% of government revenues (Kurmanov et al., 2019).

The role of raw material industries has significantly increased and became the basis for the development of Kazakhstan economy. In fact, the impact of oil and gas sector growth goes far beyond its direct contribution to GDP through demand for suppliers and related industries, the impact of oil wealth on domestic consumption, rising real estate and financial asset prices, and a real exchange rate appreciation.

In the period of 1990-2018, construction, trade, business, transportation and financial services have been enjoying growth, but these trends are the result of direct or indirect demand generated by large investments and expenditures in the oil and gas sector of Kazakhstan. The "Dutch disease," the features of which are inherent in the Kazakhstan economy, can manifest itself in an increase in the relative contribution of industries producing "non-trade goods," that is, something impossible to import, mainly services.

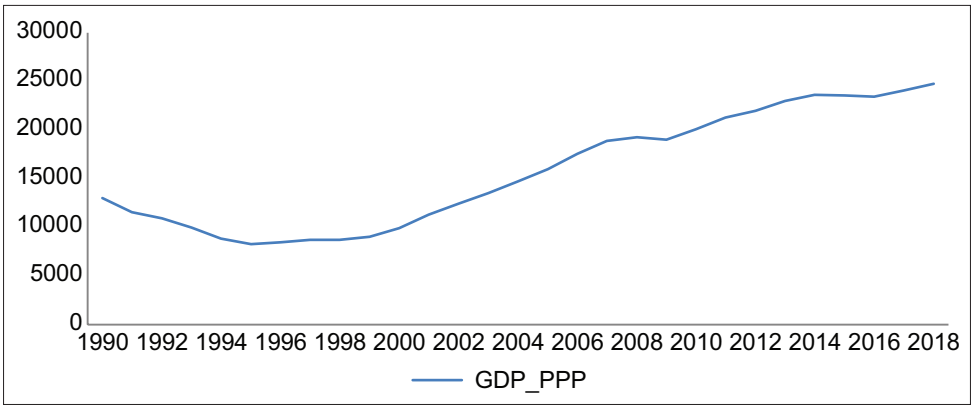
The second indicator included in the developed model is the GDP per capita. The calculated elasticity coefficient shows that with an

Figure 3: Energy imports, net, % of energy use



Source: Enerdata

Figure 4: GDP per capita PPP, US$



Source: World Bank

increase in its value by 1%, the expected energy intensity decrease shall be 0.44%.

Figure 4 illustrates the change in per capita GDP at PPP for the period of 1990-2018.

As we noted, both Kazakhstan's GDP and GDP per capita highly correlate with total energy production.

For 28 years, Kazakhstan has enjoyed an increase in GDP per capita against the backdrop of a commodity sector prosperity and rising world oil and gas prices. The growth of per capita income in Kazakhstan over this period would increase by 90%. Thus, over the past several years, the dynamics of GDP per capita has tended to stable growth influencing the GDP energy intensity. But, taking into account the fact that GDP per capita depends on energy exports, the solution to the problem of increasing the energy efficiency of the domestic economy determines the need to develop a set of measures aimed at diversifying Kazakhstan economy.

5. CONCLUSION AND POLICY IMPLICATIONS

We have obtained the following main results:

1. When constructing the economic and mathematical model of the influence of various factors on the GDP energy intensity, we have considered a number of indicators reflecting the influence of economic growth factors characterizing the development of the power sector and determining the country's living standard. Following the selection and elimination of multicollinear dependence, we have included two indicators in the developed model – Net Energy Imports and GDP per capita. These have a strong influence on the GDP energy intensity
2. The calculated elasticity coefficient shows that with an increase in the Net Energy Import value by 1%, the expected decrease in energy intensity shall be 0.85%. With an increase in GDP per capita of 1%, the expected decrease in GDP energy intensity shall be 0.44%
3. A more detailed analysis of the Net Energy Imports has shown that Kazakhstan is a net exporter of power. Oil and gas sector appears to be the key sector of Kazakhstan's economy. It directly accounts for about 15% of GDP, more than half of energy exports and more than 40% of government revenues
4. The results of our study confirm conclusions on the impact of population income growth on GDP energy intensity change made by a number of authors (Dargahi and Khameneh, 2019; Khasaev and Tsybatov, 2018; Deichmann et al., 2018; Kazmaganbetova et al., 2016). However, in Kazakhstan, the influence of GDP per capita is mediated by the export of energy resources, which is confirmed by the high correlation between GDP growth, total energy production and export

5. The commodity markets are characterized by particular price volatility. This creates a strong macroeconomic instability. Moreover, undesirable consequences for the Kazakhstan economy may arise in the case where oil prices go both low or high.

   At accelerated growth rates in oil production, structural transformations of the economy (within acceptable limits) shall not allow bringing the share of finished products closer to the share of raw materials in GDP, especially in export. This means that the country shall forever remain on the sidelines of developed countries, while its economy shall remain peripheral, backward, despite the abundant supplies of power resources.
6. Given the abundance of revenues from energy resources at a time of favorable external economic conditions, it is difficult to expect the government to abandon the impressively high growth rates that oil and gas provide. Especially that the high growth rates and the huge influx of oil revenues persisting for 28 years have already created a strong illusion about the sustainability of economic growth, and have created a false euphoria that the economy of Kazakhstan continues to grow and nothing is threatening it while there is still oil and gas. Nothing dampens people and authorities like an abundance of natural resources bringing huge surplus incomes under the favorable conditions of world markets
7. Ultimately, energy becomes not that much of a blessing as it is a brake on structural and institutional reforms, without which neither diversification or increased competitiveness of the economy, nor sustainable growth can happen. However, the right policy of the state is able to turn the abundance of resources into growth in prosperity, in the well-being of both present and future generations
8. Today, the government of Kazakhstan needs to set as its main goals reducing energy intensity and getting the economy rid of dependence on raw materials, of the world oil price volatility, and transitioning to economic growth accompanied by development. In this regard, we support the findings of such researchers as Li et al. (2014) who argue that for developing energy exporting regions, the conversion of primary energy to high value-added products is more rational for economic development and energy conservation. Therefore, there is no task more urgent than the wide diversification of the Kazakhstan economy and increasing its competitiveness. Essentially, what we need is not just diversification, but radical modernization. It is necessary to master the production of new types of finished products, most notably, its high-tech types with high added value, to update and expand their nomenclature, to achieve a qualitative upgrade of the production apparatus of the non-resource sector of the economy, and to provide all sectors with highly qualified labor.

6. ACKNOWLEDGMENT

This work was supported by the Science Committee of the Ministry of Education and Science of the Republic of Kazakhstan (grant numbers AP08052209).

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