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Energy efficiency, low-carbon energy production, and economic growth in CIS countries

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Abstract. The paper studies the peculiarities of energy efficiency increase in national economy and decrease of carbon dioxide emission for CIS countries. The conditions that allow achieving parameters of sustainable development are determined according to indexes of GDP energy intensity and carbon intensity. Focusing on the indexes of GDP energy intensity and carbon intensity dynamics as well as on carbon intensity of energy production, a real movement towards implementation of program conditions presented by international organizations is analyzed, namely, economic conversion to the model of sustainable development. The examples demonstrate both the presence of significant differences between 12 countries and the lack of fatality in these differences. At determining dependencies linear models are preferred to non-linear ones, with the explanation of reasons in each particular case. Attention to success of these countries may help to understand the advantages of conversion to the model of sustainable development and also it helps to decrease demands in terms of costs for this conversion.

1. Introduction

Russia has supported the concept of sustainable development, and this fact has determined the direction of economy competitiveness increase via decline in GDP energy intensity. WTO accession has defined timescales and the amount of this decline – by 40% during 2007-2020. However, despite significant achievements in recent years, this index is still staying almost 2.5 times higher than a worldwide average level. It may turn out that the given amount of decline in GDP energy intensity will not be achieved at the abovementioned timescales. So, the Minister of Energy of the Russian Federation A.V. Novak, during the session in April, 9, 2014, noted that the rate of decline in GDP energy intensity in 2011-2013, as compared to 2007, was sustainably lower than intended indicators. Under the conditions, when the opinion about energy reduction of world economy dominates among the experts, this lag seems to be the inefficient economy of Russia [1]. Maintenance of energy-efficiency measures will lead to decline in GDP



energy intensity by 45% to 2040, in comparison with 2010 (by 2% per year) in the Base Case, and twofold (by 2.3% per year) in the Case of «Alter Asia» («Drugaya Aziya»). Forecasted rates of decline in GDP energy intensity in Russia will become 2.8-2.1 times lower than those achieved in 2007-2008, when they amounted 5.8% on average, per year. The Base Case assumes the absence of any significant technological revolutions and breakthroughs. «Alter Asia» is the Case, where the world deals with tough resource deficiency. In this case, very favourable opportunities are created for the countries that produce energy resources, including Russia [2]. However, price decline for hydrocarbons was planned neither in the Base Case, nor in the alternative one. Therefore, the measures aimed at energy efficiency increase and environment load decrease have been delayed unintentionally.

In British Petroleum Case the results of energy efficiency policy and decline in carbon intensity are compared during 1994-2014 and 2014-2035 (Fig.1)[3].

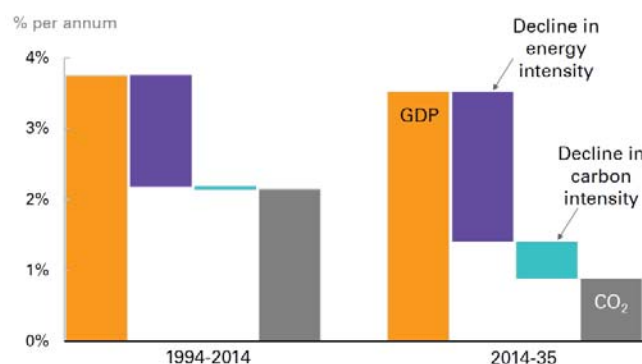


Figure 1. Separation of carbon intensity growth from GDP growth

Figure 1. shows the increase of intensive factors in primary energy production and a sharp increase of CO₂ emission decline. The conditions of CO₂ emission decline include transition to low-carbon fuel for automobiles and heating as well as the changes in the structure of power system in Russia.

Further let us consider trend data facilitating sustainable development and ecosystem stability: energy efficiency, carbon dioxide emissions in relation to GDP and the energy used, and also transition to low-carbon energy [4].

2. Decline in energy intensity

Energy intensity of a country is often used as an index of country energy efficiency. This is the ratio of total primary energy supply (TPES) to gross domestic product (GDP) of the country. According to the data of Organization for Economic Cooperation and Development (OECD), in 2000-2013 GDP energy intensity in the world economy, in general, reduces from 0.22 to 0.16 of total primary energy supply per GDP unit, which is calculated as an amount of toe (tones of oil equivalent) per GDP unit (1000 US dollars \$, 2005)[5]. At the same time, GDP energy intensity in Russia reduces from 0.49 to 0.33, in Canada – from 0.25 to 0.19. In Norway it does not change - 0.13. In contrast, in China the decline occurs from 0.29 to 0.22, in the USA – from 0.20 to 0.15, in European Union (28 countries) – from 0.14 to 0.11, in the countries of Organization for Economic Cooperation and Development – from 0.16 to 0.13, in Japan – from 0.14 to 0.11. See Table 1 [6].

An absolute leader in GDP energy intensity decline is China – 0.31. The second important country, which has achieved success, is India – 0.43. Then, follow the former socialist countries such as Estonia (0.39), Poland (0.42), and Slovakia (0.44). However, these countries are not comparable with Russia either

according to population and territory, or social and economic policy (the Eastern-European members of EU take a relaxed look at the sharp decrease in manufacturing and emigration of young staff from the countries).

Among CIS countries, Armenia is the leader in decline of energy intensity (decline by 80%). In the 1990-'s this country faced the blockade of energy supplies, and it had to provide energy-efficiency measures, regardless of economic costs. The second place in terms of energy reduction is taken by neighbouring Azerbaijan – 0.31.

Table 1. Production of toe per GDP unit according to PPP in 1990, 2000, and 2013 in CIS countries

Countries	Years			
	1990	2000	2013	2013/1990
Canada	0.28	0.25	0.19	0.68
Czech Republic	0.29	0.22	0.16	0.55
Estonia	0.61	0.30	0.24	0.39
Finland	0.25	0.22	0.19	0.76
France	0.16	0.14	0.12	0.75
ΦPIΓ	0.17	0.13	0.11	0.65
Iceland	0.34	0.36	0.48	1.41
Japan	0.13	0.14	0.11	0.85
Norway	0.15	0.13	0.13	0.87
Poland	0.33	0.20	0.14	0.42
Slovakia	0.34	0.25	0.15	0.44
Sweden	0.22	0.17	0.14	0.64
	0.16	0.12	0.09	0.56
the USA	0.24	0.20	0.15	0.63
EU–28	0.17	0.14	0.11	0.65
OECD	0.19	0.16	0.13	0.68
Brazil	0.13	0.11	0.11	0.85
China	0.70	0.29	0.22	0.31
India	0.30	0.19	0.13	0.43
Russia	0.47	0.49	0.33	0.70
Armenia	0.74	0.29	0.15	0.20
Azerbaijan	0.42	0.35	0.10	0.24
Belarus	0.62	0.38	0.19	0.31
Georgia	0.36	0.22	0.14	0.39
Kazakhstan	0.40	0.28	0.24	0.60
Kyrgyzstan	0.55	0.26	0.25	0.46
Moldavia	0.47	0.38	0.21	0.45
Tajikistan	0.31	0.33	0.14	0.45
Turkmenistan	0.64	0.69	0.42	0.66
Uzbekistan	0.83	0.93	0.32	0.39
Ukraine	0.52	0.63	0.34	0.65
World, in bulk	0.22	0.19	0.16	0.73

Although this country is a manufacturer and exporter of energy, however, Azerbaijan has become a leader in attracting foreign investment capital, and it has managed to reduce its GDP energy intensity. The third place is taken by Belarus – 30.6. This country is limited in its resources, and it tends to develop machine building and the other branches, which give a significant amount of added value [7].

Turkmenistan demonstrates the worst results among CIS countries – 0.66. This country, like Azerbaijan, is a manufacturer and exporter of energy supplies. However, the lack of investment leads to restrictions in energy intensity decline. Ukraine, similar to Belarus in terms of energy supply resources, nevertheless, appears to be at the end of the list of energy intensity decline, at the same level as Turkmenistan – 0.65. It is caused by the lack of investments in new technologies. Kazakhstan takes the third place with the index of 0.60.

Therefore, having chosen a trend for decline in primary energy intensity, it is necessary to consider possible reserves for energy efficiency increase, from the view of branch.

3. Carbon dioxide emission

Reduction in greenhouse gas emissions may serve as an additional factor to energy efficiency, because the main gas among these gases is carbon dioxide (CO₂). CO₂ emissions depend on energy intensity (the amount of energy per GDP unit) and carbon content in the energy balance (carbon per energy unit)[8]. Table 2 presents the volumes of CO₂ released in CIS countries: Azerbaijan, Belarus, Kazakhstan, Russia, Turkmenistan, Ukraine, and Uzbekistan [9].

Table 2. CO₂ emissions in 1985-2014 in CIS countries, million tons (CO₂)

	1985	1990	1995	2000	2005	2010	2014	2014/1990
Azerbaijan	53.6	59.0	36.7	30.5	34.7	25.6	33.5	56.8%
Belarus	105.4	113.1	61.9	61.0	64.4	67.3	76.7	67.8%
Kazakhstan	232.3	250.9	167.8	124.1	149.4	168.5	188.6	75.2%
Russia	2284.5	2356.2	1714.7	1557.9	1594.5	1646.1	1657.2	70.3%
Turkmenistan	33.9	35.7	24.5	38.1	49.8	65.4	78.1	218.8%
Ukraine	686.5	755.4	382.8	342.2	336.5	300.5	243.3	32.2%
Uzbekistan	116.8	122.9	112.8	122.4	111.0	101.6	120.5	98.0%

The indexes presented in Table 2 show that the leader of reduction is Ukraine (32.2%), the second place is taken by Azerbaijan (56.8%), the third – Belarus (67.8%). In this case, the growth of emissions is observed in Turkmenistan – 218.8%. Russia has a middle position with the amount of 70.3%.

Being tabulated, the results obtained in CO₂ emission reduction do not take in account many factors, from the influence of GDP dynamics to the whole complex of measures on carbon intensity decline in the energy production of the country.

The following table characterizes dependence of CO₂ emissions on production output determined by purchasing power parity in dollars, 2005 (shortly, CO₂/GDP PPP). It is measured in CO₂ kg per US dollar, at 2005 values.

The analysis of Table 3 allows making the following conclusion. Firstly, it is observed that index CO₂/GDP PPP varies significantly for these countries. So, in 2013 the leader of the countries with low carbon intensity is Tajikistan (0.19), the second is Azerbaijan (0.21), and the third – Georgia (0.24). Let us consider another pole. The country with the highest level of GDP carbon intensity is Turkmenistan (1.04), and Ukraine (0.77) takes the second place. Then follows the group of countries with a small variation in indexes: Kazakhstan (0.72), Uzbekistan (0.71), and Russia (0.70) [10]. It indicates serious differences in the economic structure of the chosen countries. Russia has great reserves for reduction of CO₂ emissions.

Russia's position behind the leading group seems to be unsurpassable, but the previous successes in this index decline in recent years present prospects for future [11].

Table 3. Dynamics of GDP carbon intensity according to PPP, 1999-2013, in CIS countries, CO₂ kg per US dollar, at 2005 values

	1999	2004	2009	2010	2011	2012	2013	Trend
Armenia	0.44	0.28	0.25	0.24	0.26	0.28	0.26	$y = -0.0138x + 0.4193$
Azerbaijan	0.90	0.58	0.20	0.18	0.21	0.22	0.21	$y = -0.0548x + 0.8879$
Belarus	0.88	0.64	0.45	0.45	0.41	0.41	0.41	$y = -0.0339x + 0.8509$
Georgia	0.35	0.19	0.24	0.21	0.24	0.25	0.24	$y = -0.0045x + 0.2765$
Kazakhstan	0.99	0.76	0.76	0.78	0.77	0.73	0.72	$y = -0.0084x + 0.8496$
Kyrgyzstan	0.54	0.48	0.48	0.45	0.50	0.67	0.56	$y = 0.0057x + 0.4528$
Moldavia	0.96	0.76	0.63	0.63	0.59	0.58	0.47	$y = -0.0294x + 0.9428$
Russia	1.26	0.93	0.75	0.78	0.76	0.71	0.70	$y = -0.0385x + 1.2056$
Tajikistan	0.42	0.26	0.17	0.16	0.16	0.17	0.19	$y = -0.0141x + 0.3515$
Turkmenistan	1.75	1.91	1.22	1.27	1.20	1.12	1.04	$y = -0.0569x + 1.9954$
Uzbekistan	2.17	1.69	1.01	0.91	0.92	0.86	0.71	$y = -0.1120x + 2.3473$
Ukraine	1.52	1.03	0.81	0.83	0.83	0.81	0.77	$y = -0.0523x + 1.4420$

4. Conclusion

By 2013, Russia has stayed the country with a high level of GDP energy intensity, provided that the decline of this index is the lowest among those in CIS countries, but it is comparable with the world level of decline. It is necessary to range the following countries in descending order according to the index of energy intensity decline: Armenia, Azerbaijan, Belarus, Georgia and Uzbekistan, Moldavia and Tajikistan, Kyrgyzstan, Ukraine, Turkmenistan, and Russia. As to the level of CO₂ emissions per US dollar, 2005 (GDP PPP), Russia takes the middle position. The leader in CO₂ emission reduction in 1990-2014 is Ukraine – 32.2%, and the «anti-leader» is Turkmenistan – 218.8%. According to the rate of gas emission reduction, Russia has the fourth place. Uzbekistan, Turkmenistan, and Azerbaijan are placed gradually ahead of Russia.

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