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Cross-country Analysis of the Comparative Efficiency of Government Support for Coal and Lignite Production

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ABSTRACT

In this research, we applied the DEA method (data envelopment analysis) for a cross-country analysis of the comparative efficiency of government support for coal production in eight countries: The leading producers of coal and lignite, three OECD countries with developed economies (the USA, Germany, and Australia), four BRICS countries with developing economies and emerging markets (China, India, Russia, and South Africa), and Indonesia – the largest producer of coal and lignite in Southeast Asia from 2013 to 2018. An extended version of the DEA method allowed us to evaluate not only technicalities, but also price efficiency of budget support for natural gas production in the considered countries. The data for the empirical model characterizing the volume of financial support to oil producers through budgetary transfers and tax expenditures was taken from the OECD statistical base. The obtained results indicate low efficiency of state support for coal and lignite production in Russia, the industry that is responsible for the largest generation and emission of greenhouse gases. In accordance with international obligations, Russia should solve this problem. To achieve this goal, the government should legislatively limit the funding of coal projects and exclude coal projects from the sphere of credit and export agencies, development banks, and state banks.

Keywords: Energy Subsidies, Government Support, Fiscal Measures, Coal and Lignite Production, Operational Environment, DEA Method
JEL Classifications: H39, H54, C60

1. INTRODUCTION

Although a transition to a low-carbon economy is a globally recognized objective, government subsidies on fossil fuels (oil, natural gas, and coal) have not been ended. Further, they are two or 3 times higher than subsidies on the development of renewable energy sources (RES) (Update on Recent Progress…, 2018). Many governments use energy subsidies as a tool for socio-economic development or in case of a "market failure" (Gerasimchuk, 2012). At the same time, according to a well-known proposition of economic theory, subsidies are associated with negative economic externalities that manifest themselves as the inefficient use of resources since subsidies distort the parameters of economic decision-making, thereby stimulating inefficient distribution of all types of resources, as well as incurring losses to the national economy. Eventually, society has to cover all the arising costs (Lunden and Fiertoft, 2014).

A leading role in the fight against climate change is to be played by the G-20 countries as they generate 79% of the world's greenhouse gas emissions. In 2009, the G-20 countries made a rather vague commitment to eliminate in the medium term the inefficient subsidization of fossil fuels that encourages wasteful consumption. However, after 10 years, the G-20 governments are still allocating billions of dollars to support the production and consumption of fossil fuels, with at least USD 63.9 billion annually provided for the extraction and burning of coal, the most dangerous type of fuel for the climate and the environment. Coal-fired power plants and thermal power plants – the main source of CO_2 emissions – receive USD 47 billion annually in the form of government subsidies in the G-20 countries, although even in 2013-2014, this support was smaller and amounted to USD 17 billion. Furthermore, another USD 17 billion per year is allocated by the G-20 countries to coal projects in other countries (Gencsu et al., 2019).

For instance, in 2016 and 2017, the Russian government annually invested at least USD 748 million (48,459 million rubles) in new coal capacities and USD 28 million (1,775 million rubles) (Gerasimchuk and Roberts, 2019) in the development of deposits and coal mining. In addition, the Russian government provides substantial support to the coal industry, and in particular coal export, through preferential railway tariffs. The Russian railway tariff for the transportation of one ton of grain or flour for 1,650 kilometers is 860 rubles, and for coal – 520 rubles. According to the International Energy Agency (IEA), in 2018, using the mechanism of regulated electricity tariffs (part of which is generated with coal), the support to coal producers from the Russian government was estimated at USD 14.3 billion. Some remote Russian regions receive subsidies from the federal budget for the purchase of coal for heating, and the total amount of these subsidies by 2018 amounted to 3.7 billion rubles (more than USD 59 million).

As a member of the G-20, in 2009, Russia pledged to abandon inefficient subsidies for fossil fuels in the medium term, and as a signatory to the UN Convention on Biological Diversity, it is obligated to end environmentally harmful subsidies by 2020, with coal being one of the most important of these. Nevertheless, Russia has not published any plans to abandon either the use of fossil fuels or its state support of the industries. Instead, the country, where 65% of electricity is generated from fossil fuels, is in the process of constructing new coal fired power plants. At the same time, during the climate change negotiations in Bonn, the Russian delegation claimed that transition to low-carbon energy will be carried out primarily by employing energy efficiency and energy saving measures.

Various international environmental funds led by the International Monetary Fund (IMF) opted for reducing energy subsidies and believe that their funding is expensive for a state and may impede government efforts to reduce the budget deficit. Subsidies also contribute to excessive energy consumption, which accelerates the depletion of natural resources and reducing incentives for investment in other non-polluting energy sectors.

In addition, back in 2009, the G-20 countries called for phasing out fossil fuel subsidies worldwide and reiterated this call in 2012. In line with recent activities of the G-20, the following criteria for classifying energy subsidies seem particularly relevant: the type of subsidized energy source (i.e., fossil fuel or other types of energy carriers) and the efficiency of subsidies.

The type of energy carrier should be considered, primarily from the perspective of climate change prevention and the elimination of subsidies for fossil fuels, which is constantly discussed during the G-20 negotiations. According to modern studies of international organizations, the directions and types of subsidies in the fuel and energy sector are extremely diverse. However, using the existing classifications, one can generalize and identify subsidies that are not explicitly stated by the countries that provide them.

Along with the problem of identifying subsidies, their scale and efficiency should be explored. In this research, we performed a cross-country analysis of the comparative efficiency of energy subsidies, in particular, government support for coal and lignite production in the OECD countries with developed economies, the leading producers and exporters of coal and lignite (i.e., the U.S., Germany, and Australia), four of the five developing BRICS countries (China, India, Russia, and South Africa), and the largest producer of coal in Southeast Asia for the period from 2013-2018 (i.e., Indonesia).

The analysis was performed in line with the methodology for evaluating the OECD subsidies. The structure of OECD subsidies includes the following: budget expenditures (including tax expenditures) that imply direct state transfers; market price support and market transfers associated with the introduction of a "price floor" to support producers, a "price ceiling" to protect consumers, respectively, and lost revenues (from state assets) that actually take the form of indirect subsidization, which operates similar to a tax benefit. It should be noted that the OECD has developed a number of methods to assess the scale of financial support to a producer and a consumer through energy subsidies, even with limited data. The OECD documents often use the term "government support measures" for the broadest interpretation of the subsidies in the fuel and energy complex.

2. METHODOLOGY

The efficiency of state power and its governing bodies can be increased by developing formalized methods and criteria for quantifying the efficiency of the entire public sector (Onrubia-Fernández and Jesús Sánchez Fuentes, 2017). Currently, the most common tools for evaluating the efficiency of the state activities are non-parametric methods for analyzing the operational environment (data envelopment analysis, DEA [Emrouznejad et al., 2008]), in which the state consumes the resources of society and produces public goods (e.g., safety, health, and infrastructure) (Akhremenko, 2013a).

However, the process of converting resources into results is not considered within the DEA method, i.e., the system is represented as a "black box," efficiency is determined as a ratio of costs and results, but it is not based on the internal characteristics of decision-making units (DMUs). Therefore, this approach does not consider the structure of the analyzed systems or comprehensively explore their characteristics.

In the quantitative evaluation of the efficiency of the public sector, as a rule, one takes budget expenditures for providing various public goods as input variables, whereas the achieved level of public welfare in a particular area is considered as output parameters of the model. The DEA method. A nonparametric method for evaluating the technical efficiency of a set of similar companies was first developed by Farrell (1957). Later, this method was substantially developed in the works of Debreu

(1951), Koopmans (1951), Forsund and Hjalmarsson (1974), Charnes et al. (1985), and Tone (2001).

Nevertheless, all traditional DEA models can be used to measure the technical efficiency of DMUs, but they cannot be applied for benchmarking and ranking DMUs because one needs to know price efficiency of the compared DMUs to apply them. To overcome the above disadvantages of traditional DEA methods, Khezrimotlagh et al. (2013) developed an approach that evaluates the efficiency of companies according to the ε-KAM method (Kourosh and Arash Method). It uniformly connects two concepts and provides estimates both for calculating technical and price efficiency.

In this research, we performed a cross-country analysis of the comparative efficiency of energy subsidies, specifically, government support for coal and lignite production in eight countries, which are the leading producers and exporters of coal and lignite: several OECD countries with developed economies (the U.S., Germany, and Australia), four of five of the developing BRICS countries (China, Brazil, and Russia) for the period from 2013 to 2018 with the ε-KAM method.

The DEA method simultaneously uses input and output indicators, which sometimes leads to incorrect results because budget investment flows precede the results, though they do not occur at the same time. Therefore, in this study the budget investment flow was replaced with accumulated budget investments (Akhremenko, 2013). For example, considering the data from 2010 to 2013, the input indicator of the model is the sum of X(2010) + X(2011) + X(2012), and the output indicator is Y(2013).

3. DATA

In the empirical model, the cross-country analysis of the comparative efficiency of state support for coal and lignite production was performed for a sample of eight countries: three OECD countries (U.S., Germany, and Australia), four BRICS countries (China, India, Russia, and South Africa), and Indonesia. The initial data covered the period from 2013 to 2018 and were taken from the statistical databases of the Organization for Economic Co-operation and Development (OECD).

We selected the following annual indicators for each country in the sample:

X1 – annual budgetary transfers to coal and lignite producers, million units in national currency

X2 – annual tax expenditures for coal and lignite producers, million units in national currency

Y1 – annual production of coal and lignite, million tons.

To recalculate government support indicators X1 and X2 expressed in the national currency of each country as a share of the country’s GDP, we used annual data on the countries’ GDP from the statistical database of the international organization – OECD data, gross domestic product (GDP).

Table 1 presents data on the world’s annual production of coal and lignite (million tons), including country unions – OECD, BRICS, G7, Europe, and the European Union; some OECD countries – the U.S., Germany, Australia; and some BRICS countries – China, India, Russia, South Africa, and Indonesia for the period from 2010 to 2018.

As can be seen from Table 1, over the period from 2010 to 2018 the production of coal and lignite was increasing worldwide, with an average growth rate of 2.8% per year, although the global dynamics of coal and lignite production is uneven: before 2013 coal and lignite production was steady increasing, while later there was a decrease up to 2017.

The global growth in the production of coal and lignite was due to the BRICS countries, which are responsible for the annual increase of 4.7% from 2000 to 2018. Other country unions reduced the production of coal and lignite over the same period of time: In the OECD, the annual decline was 0.8%, in the G7 – 0.8%, in Europe – 1.2%, in the EU – 1.8%. For individual countries, the largest annual increase in the production of coal and lignite from 2000 to 2018 could be observed in Indonesia (10.4%), China (5.4%), India (4.7%), Russia (3.0%), Australia (2.8%), and South Africa (0.8%). Germany and the U.S. decreased the annual production of coal and lignite over this period – 1.1% and 1.9%, respectively.

Table 2 shows numerical values of state (fiscal) support for the production of coal and lignite in some OECD countries with developed economies (the U.S., Germany, and Australia), the BRICS countries (China, India, Russia, and South Africa), and Indonesia for 2010-2018. The amount of subsidies is given in the national currency of the country (million units). The last column of Table 2 presents the data on the GDP of the considered countries (million units of the national currency).

4. RESULTS

Table 3 presents the results of the model experiments with the ε-KAM method for the cross-country analysis of the comparative efficiency of government support for coal and lignite production of the largest coal and lignite producers in the OECD (the U.S., Germany, and Australia), in the BRICS (China, India, Russia, and South Africa), and Indonesia for the period from 2013 to 2018. As follows from Table 3, among the OECD countries with developed economies – the largest producers of coal and lignite, the United States and Australia have the highest technical and price efficiency of state support (numerically expressed in the units of the country’s GDP) for the production of coal and lignite in the analyzed sample of eight countries. In 2018, in these two countries, state support for coal and lignite production was at the borderline of technical and price efficiency (KAM-score=1.0). This, according to the ε-KAM method, means that there is no need to change the combination of input and output indicators of the model.

For the period from 2013 to 2018, in the analyzed countries the average values of the technical and price efficiency of state support (numerically expressed in units of the country’s GDP) of natural gas production were also highest in the U.S. and Australia. The U.S. had the highest averaged price efficiency of state support

Table 1: Production of coal and lignite in some OECD countries – the U.S., Germany, Australia; and some BRICS countries – China, India, Russia, South Africa, and Indonesia for the period, 2010-2018

Countries	2010	2011	2012	2013	2014	2015	2016	2017	2018	2000-2018 (%/year)
World	7389	7834	7945	8014	7973	7756	7336	7542	7683	2,8
OECD	2103	2111	2054	2025	2055	1935	1745	1792	1768	−0,8
G7	1267	1282	1214	1178	1187	1071	903	943	910	−1,9
BRICS	4446	4746	4876	4951	4900	4862	4610	4751	4911	4,7
Europe	705	739	730	690	664	654	623	634	629	−1,2
European Union	564	591	591	559	540	528	482	491	473	−1,8
Germany	184	189	197	191	187	185	176	175	169	−1,1
Russia	300	297	331	328	334	353	368	388	412	3,0
United States	996	1006	932	904	918	814	661	703	684	−1,9
China	3316	3608	3678	3749	3640	3563	3268	3376	3474	5,4
India	570	582	603	610	657	683	712	725	764	4,7
Indonesia	325	405	451	492	491	455	463	469	474	10,4
Australia	436	415	435	458	489	512	500	499	502	2,8
South Africa	255	253	259	256	261	255	255	256	257	0,8

Source: Global Energy Statistical Yearbook, 2019

Table 2: The volume of state support for the production of coal in the U.S., Germany, Australia, China, India, Indonesia, Russia, and South Africa for 2010-2018

Indicators	X1–Fossil fuel subsides, budgetary transfers, mln units	X2–Fossil fuel subsides, tax expenditure, mln units	Y1– Production (annual), coal and lignite, mln ton	GDP, in national currency, mln units
2010,U.S.	3956.33	1051.66	996.	1.49921*10^7
2011,U.S.	491.587	1074.97	1006.	1.55426*10^7
2012,U.S.	1469.18	862.052	932.	1.6197*10^7
2013,U.S.	597.916	552.134	904.	1.67849*10^7
2014,U.S.	633.916	480.794	918.	1.75217*10^7
2015,U.S.	634.57	486.575	814.	1.82193*10^7
2016,U.S.	671.524	384.445	661.	1.87072*10^7
2017,U.S.	666.033	375.349	703.	1.94854*10^7
2010,DEU	0.	192.756	184.	2.57452*10^6
2011,DEU	0.	177.607	189.	2.69916*10^6
2012,DEU	0.	160.75	197.	2.75952*10^6
2013,DEU	0.	142.279	191.	2.8307*10^6
2014,DEU	0.	131.529	187.	2.94298*10^6
2015,DEU	0.	115.084	185.	3.04595*10^6
2016,DEU	230.	96.1115	176.	3.15411*10^6
2017,DEU	230.	95.9722	175.	3.28133*10^6
2010,AUS	17.6221	2.73945	436.	1.36316*10^6
2011,AUS	232.54	0.620744	415.	1.46749*10^6
2012,AUS	3.95603	0.620745	435.	1.51529*10^6
2013,AUS	240.891	0.620744	458.	1.56812*10^6
2014,AUS	9.02282	4.66964	489.	1.614*10^6
2015,AUS	10.9553	3.63949	512.	1.6408*10^6
2016,AUS	43.4739	0.815767	500.	1.70525*10^6
2017,AUS	8.82774	0.62	499.	1.80793*10^6
2010,CHN	0.8584	83.8	3316.	4.12119*10^7
2011,CHN	5.97525	88.4	3608.	4.8794*10^7
2012,CHN	0.8484	101.	3678.	5.3858*10^7
2013,CHN	100.142	121.	3749.	5.92963*10^7
2014,CHN	2254.68	141.7	3640.	6.41281*10^7
2015,CHN	6526.49	254.6	3563.	6.85993*10^7
2016,CHN	4847.54	265.6	3268.	7.40061*10^7
2017,CHN	4.82053	326.486	3376.	8.20754*10^7
2010,IND	4490.	1568.	570.	7.63447*10^7
2011,IND	4061.2	1651.1	582.	8.74034*10^7
2012,IND	4997.91	1590.1	603.	9.94401*10^7
2013,IND	5596.55	2610.66	610.	1.12335*10^8
2014,IND	4532.6	2600.	657.	1.2468*10^8
2015,IND	5823.5	2310.6	683.	1.37719*10^8
2016,IND	1700.	3360.6	712.	1.53624*10^8
2017,IND	2255.5	4774.5	725.	1.7095*10^8
2010,IDN	6000.	2.*10^6	325.	6.86413*10^9

(Contd...)

Table 2: ***(Continued)***

Indicators	X1–Fossil fuel subsides, budgetary transfers, mln units	X2–Fossil fuel subsides, tax expenditure, mln units	Y1– Production (annual), coal and lignite, mln ton	GDP, in national currency, mln units
2011,IDN	6000.	9.379*10^6	405.	7.83173*10^9
2012,IDN	6000.	8.83118*10^6	451.	8.6157*10^9
2013,IDN	6000.	8.82137*10^6	492.	9.54613*10^9
2014,IDN	184800.	7.46167*10^6	491.	1.0569*10^10
2015,IDN	92400.	6.21951*10^6	455.	1.1526*10^10
2016,IDN	93824.8	2.*10^6	463.	1.2401*10^10
2017,IDN	98774.2	2.*10^6	469.	1.3587*10^10
2010,RUS	259.	197.127	300.	4.9879*10^7
2011,RUS	313.	416.883	297.	6.02825*10^7
2012,RUS	271.1	798.096	331.	6.81639*10^7
2013,RUS	129.757	781.598	328.	7.31339*10^7
2014,RUS	387.64	814.727	334.	7.91997*10^7
2015,RUS	339.838	877.931	353.	8.32326*10^7
2016,RUS	216.554	1197.08	368.	8.60436*10^7
2017,RUS	270.87	1797.1	388.	9.21013*10^7
2010,ZAF	1604.04	3291.	255.	2.74808*10^6
2011,ZAF	1777.7	3288.	253.	3.02242*10^6
2012,ZAF	12599.9	5035.	259.	3.24525*10^6
2013,ZAF	6146.81	7056.	256.	3.54033*10^6
2014,ZAF	6930.61	8016.	261.	3.79649*10^6
2015,ZAF	7927.09	10086.	255.	4.04256*10^6
2016,ZAF	8467.04	5604.	255.	4.34877*10^6
2017,ZAF	9801.21	5304.	256.	4.65923*10^6

Source: The authors' calculations with the data from Global Energy Statistical Yearbook, 2019 and OECD inventory of support measures for fossil fuels database (OECD, 2019)

Table 3: Indicators of the efficiency of state support for coal production in the U.S., Germany, Australia, China, India, Indonesia, Russia, and South Africa, 2010-2018

Efficiency Indicators	KAM-score, ε=10-7, technical efficiency	KAM-score, ε=10-1	KAM-score, ε=1.0. Price efficiency
2013,U.S.	0.252	0.401	0.53
2014,U.S.	0.289	0.38	0.59
2015,U.S.	0.34	0.34	0.38
2016,U.S.	0.342	0.4	0.804
2017,U.S.	0.48	0.521	0.863
2018,U.S.	1.	1.	1.
Mean(2013-2018),U.S.	0.453	0.507	0.695
2013,DEU	0.106	0.109	0.109
2014,DEU	0.103	0.106	0.106
2015,DEU	0.104	0.106	0.106
2016,DEU	0.104	0.104	0.104
2017,DEU	0.105	0.105	0.105
2018,DEU	0.105	0.105	0.105
Mean(2013-2018),DEU	0.105	0.106	0.106
2013,AUS	0.318	0.38	0.43
2014,AUS	0.465	0.465	0.465
2015,AUS	0.501	0.501	0.501
2016,AUS	0.655	0.687	0.688
2017,AUS	0.838	0.883	0.887
2018,AUS	1.	0.988	0.992
Mean(2013-2018),AUS	0.630	0.653	0.663
2013,CHN	0.1022	0.1022	0.1022
2014,CHN	0.102	0.102	0.102
2015,CHN	0.102	0.1019	0.1019
2016,CHN	0.1023	0.1024	0.1024
2017,CHN	0.1033	0.1035	0.1035
2018,CHN	0.104	0.1041	0.1041
Mean(2013-2018),CHN	0.103	0.103	0.103
2013,IND	0.111	0.112	0.112
2014,IND	0.111	0.112	0.113
2015,IND	0.111	0.116	0.116
2016,IND	0.113	0.114	0.114
2017,IND	0.115	0.116	0.116
2018,IND	0.115	0.115	0.115
Mean(2013-2018),IND	0.113	0.113	0.113

(Contd...)

Table 3: *(Continued)*

Efficiency Indicators	KAM-score, ε=10-7, technical efficiency	KAM-score, ε=10-1	KAM-score, ε=1.0. Price efficiency
2013,IDN	0.217	0.218	0.220
2014,IDN	0.22	0.23	0.230
2015,IDN	0.221	0.223	0.223
2016,IDN	0.197	0.198	0.198
2017,IDN	0.196	0.198	0.198
2018,IDN	0.179	0.180	0.183
Mean(2013-2018),IDN	0.205	0.206	0.207
2013,RUS	0.132	0.167	0.175
2014,RUS	0.129	0.132	0.145
2015,RUS	0.14	0.144	0.158
2016,RUS	0.181	0.183	0.196
2017,RUS	0.277	0.287	0.289
2018,RUS	0.389	0.392	0.41
Mean(2013-2018),RUS	0.208	0.218	0.229
2013,ZAF	0.217	0.218	0.22
2014,ZAF	0.22	0.23	0.23
2015,ZAF	0.221	0.223	0.223
2016,ZAF	0.197	0.198	0.198
2017,ZAF	0.196	0.198	0.198
2018,ZAF	0.179	0.18	0.183
Mean(2013-2018),ZAF	0.205	0.206	0.207

Source: Compiled by the authors, the calculations performed according to the proposed methodology using the data from Tables 1 and 2

for coal and lignite production (KAM-score=0.695), although Australia had the highest averaged technical efficiency over the same period of time (KAM-score=0.630).

The lowest indicators of both technical and price efficiency of state support for coal and lignite production (numerically expressed in units of the country's GDP) among the analyzed eight countries were shown by the developing BRICS countries – China and India, as well as Germany: efficiency estimates (KAM-score) ranged from 0.100 to 0.115. According to Table 3, in 2018 Russia had rather low values of both technical and price efficiency of state support for coal and lignite production (numerically expressed in units of the country's GDP) among the analyzed eight countries (KAM-score=0.208, ε=10-7 and KAM-score=0.229, ε=1.0), which are very far from the borderline and the technical and price efficiency of state support for natural gas producers in the analyzed countries.

In terms of both technical and price efficiency of state support for coal and lignite production (numerically expressed in units of the country's GDP) for the period from 2013 to 2018, Russia's indicators were comparable to those of Indonesia and South Africa, although Russia had slightly higher values than these two countries.

Thus, according to the conducted research on the comparative efficiency of state support for coal and lignite production (expressed in units of the country's GDP) in several OECD developed economies (the U.S., Germany, and Australia), several BRICS emerging economies (China, India, Russia, and South Africa), and the largest producer of coal in Southeast Asia – Indonesia, over the period from 2013 to 2018 Russia had lower efficiency than the OECD countries with developed economies (the U.S. and Australia), which means that Russia's state support for energy subsidies should be reformed.

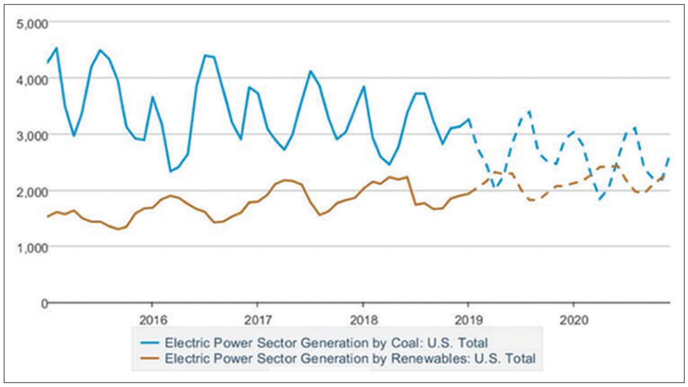
A valuable example for Russia in reforming the state support for energy subsidies is more than a century of experience of the U.S. in regulating subsoil use (Atnashev, 2016) and removing a number of barriers that impede the natural development of this business. The main difference between the United States and other mining countries is the minimal regulation of subsoil use and competitive structure of the industry, where hundreds of small and medium-sized companies compete with leaders, constantly testing new technological ideas. In addition to the minimum regulation of subsoil use, the country needs an effective financial market and investments protection.

A very alarming signal for the global coal industry is the fact that in April 2019 the share of renewable energy in the total electricity generation in the U.S. exceeded the share of coal (Figure 1), which for the 1st time reflects seasonal factors and long term trends, such as declines in the consumption of coal and renewable energy, according to the Energy Information Administration (EIA [n.d.]).

In April 2019, when US electricity demand is often at its lowest due to moderate temperatures, renewable energy sources, including hydropower, account for 23% of US electricity production, with coal-fired plants making up for 20% of US electricity generation. There is a long-term trend in the US structure of electricity generation: Coal production has declined significantly from its peak that was a decade ago. Since 2015, US coal-fired power plants have decreased their production by 47 GW, while, according to the EIA, almost no new coal-producing facilities have been launched.

Thus, the decades of development and implementation of innovations and investments in renewable energy sources contribute to a gradual reduction in the cost of electricity generation from renewable sources (Bloshenko et al., 2017), and they become more competitive compared to coal. In addition, coal-fired power plants in the U.S. are gradually exhausting their potential, and their maintenance becomes very expensive.

Figure 1: Generation of electricity in the United States through coal combustion and renewable energy for 2015-2019 and a forecast up to 2025, 1000 MegaWattHours per day



Source: US energy information administration

In addition, innovative technologies for the extraction of oil and natural gas from shale have led to a significant increase in oil and gas production in the United States. Due to a sharp decline in natural gas prices in 2016, the U.S. may stop using coal as the main source of electricity production, which it used to be for most of the 20th century. Now the coal industry has also experienced the influence of clean sources, such as solar, wind, hydro and bioenergy. Thus, in the long run, coal may also lose the second place in the list of key sources of electricity.

All these factors have led to a rapid deterioration in the coal industry, which reflects a fundamental shift in the global energy sector related to the fact that renewable energy is developing faster than traditional energy based on coal. Russian coal industry, which is mainly focused on increasing coal export, should review the development strategy of the whole field. The decline in coal exports and falling prices are inevitable, and this can occur very soon (Chikunov et al., 2019). Categorical reluctance to see this objective situation can lead to large-scale negative economic and social consequences, especially in the regions (for example, in Kuzbass) whose economy is focused on extraction and export of coal.

In such a situation it seems extremely short-sighted to subsidize the production of coal from the budget (transportation by rail) and threaten the health of the population, agricultural land and ports infrastructure for short-term prosperity of coal exporters. The research findings indicate the poor quality of Russian state administration and institutions as they are incapable of pursuing an effective budget and energy policy (Ponkratov, 2014). There is an urgent need to reform energy subsidies, to create a single mechanism for monitoring and evaluating the funding of subsidies on fossil fuels according to the set objectives and with special focus on their social and environmental impacts.

5. CONCLUSIONS

The research findings of cross-country (the U.S., Germany, Australia, China, India, Indonesia, Russia, and South Africa) analysis of the comparative efficiency of state support for coal and lignite production in 2013-2018 indicate the low result of Russia. Coal and lignite production is responsible for the largest generation and emission of greenhouse gases into the atmosphere and should be stopped in accordance with Russia's international obligations. To do this, the government should legislatively limit the funding of coal projects and exclude coal projects from the sphere of credit and export agencies, development banks, and state banks.

Comprehensive research should be conducted on the economic and financial implications of ending fossil fuel subsidies. In this regard, DEA models for evaluating the relative efficiency of government support for energy subsidies can be a powerful tool to support governments in the complex and crucial task of reforming the countries' energy policies in line with global climate goals.

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