

Trends in the energy development of the Russian Federation and its Asian regions in the first half of the 21st century in the context of Russia's energy ties with the countries of northeast Asia

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Abstract. The present paper deals with the role of the Asian regions of Russia (Siberia and the Russian Far East) in the production and consumption of energy resources in the country for the period up to 2050. The focus is on the dynamics and structure of energy resources outflows from the Asian regions of the country to the European part of the country and for exports to European and Asian destinations.

Keywords: energy sector, Asian regions of Russia, Northeast Asian (NEA) countries, energy resources, projection, scenarios, production, consumption, exports, prices

1 Introduction

The Asian regions of Russia (Siberia and the Russian Far East) have unique reserves of energy resources of all-Russian and international importance.

Currently, more than 80% of Russia's energy resources are produced in its Asian regions, including 71% of the country's oil, 97% of natural gas, more than 95% of coal; more than 30% of the country's electricity is produced there as well.

In recent years, a lot of work has been done in Russia to create a list of policy documents that define the strategic development of the energy industry in the East of the country so as to take into account mutually beneficial energy cooperation between Russia and the NEA countries in the energy sector [1–4].

The Melentiev Energy Systems Institute SB RAS, also makes a certain contribution to shaping the Eastern Energy Policy, see, for example, [5].

In the materials of the program documents, much attention is paid to the Asian regions, the development of which can give an additional impetus to the development of the energy sector of the country. The Energy Strategy notes that a more dynamic growth of consumption and production of energy resources is expected in these regions, given that they are associated with the main prospects for increasing Russian energy supplies to the countries of Northeast Asia.

The development of the energy sector of Russia and its Asian regions in the long term will depend on a number of factors, among which it is important to be aware of the changes in the projection of economic development and energy consumption levels in the country and its Asian regions; in the development of the resource and raw material base of the energy sector; in the pace of scientific

and technological advances in the energy sector; in the dynamics of fuel and energy prices in domestic markets of Russia; in the international energy markets situation.

2 Modelling tools

To estimate the effect of prospective factors on the development of the energy sector of the Asian regions we employed the basic scheme of hierarchical modelling developed at the Melentiev Energy Systems Institute, SB RAS [6], at the core of which is the dynamic model of optimization of the territorial and production structure of the country's energy sector (Figure 1), [7].

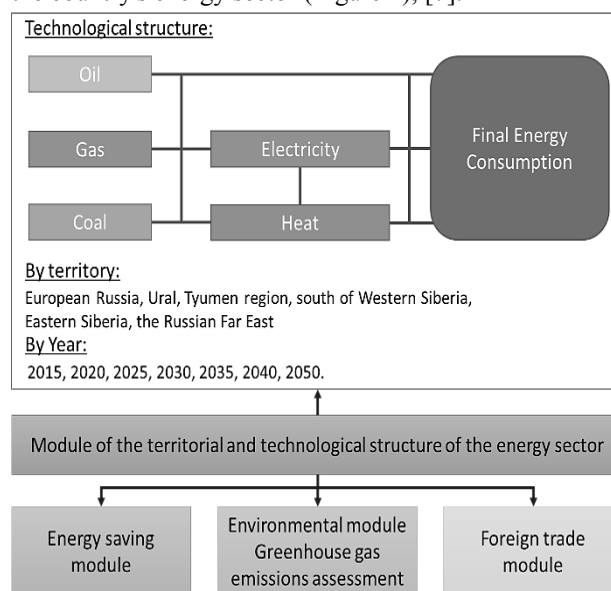


Fig. 1. Structure of the dynamic optimization model of the country's energy sector

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The model describes the process of development of the territorial and production structure of the energy sector up to 2050 in dynamics (modelled in five-year increments) as applied to large aggregated regions defined based on their geographical location.

3 Research findings

The model-based studies enabled us to form a well-balanced rational structure of regional energy sector development for the country as a whole and for each of the Asian regions (Western and Eastern Siberia, the Russian Far East) and outline their role in the energy sector of the country.

Backed by the program documents [1–4, 8] and other materials [9–11], as well as by the authors' previous research [12–15], we are able to identify a number of trends in the development of the energy sector of the country and its Asian regions to 2035 and with a view to 2050.

Below we study two scenarios of Russia's energy sector development to 2050: the conservative scenario and the more optimistic target scenario. The aggregated macroeconomic indicators of the country's economic development and corresponding energy consumption levels are shown in Table 1. The lower boundary of the indicator change range corresponds to the conservative scenario, while the upper boundary corresponds to the target scenario.

Table 1. Projection of economic development and energy consumption in Russia

Indicator	2015	Projection		
		2025	2035	2050
GDP*, bln. USD	1.555	1.850-2.105	2.300-2.960	3.160-4.610
GDP growth rate as compared to 2015, %	100	119-135	148-190	196-286
Average annual GDP growth rate, %	-	1.7-3.1	2.2-3.5	2.1-3.0
Population, mln. people	146	146	145-146	145-147
GDP per capita, thous. USD per person	10.7	12-14	16-20	22-31
Domestic primary energy consumption, mln. tce	964	1.073-1.091	1.143-1.174	1.144-1.190
Primary energy consumption growth rates as compared to 2015, %	100	111-113	118-122	119-123
GDP energy intensity, tce per thous. USD	0.62	0.56-0.53	0.5-0.4	0.4-0.3
Energy intensity decrease rate as compared to 2015, %	100	92-87	79-66	59-43

Note: reported in constant 2015 prices.
Sources: [1,8], estimates by the authors

Average annual GDP growth rates for assumed scenarios were covered within the following ranges: 1.7–3.1% for the period between 2015 and 2025 and 2.2–3.5% for the period between 2026 and 2035. It is assumed that in the years to come (2036 to 2050) the GDP growth rate will drop to 2.1% under the conservative scenario, and to 3.0% under the target scenario.

One of the prerequisites for the assumed scenarios of economic development of Russia to materialize is the

growth (as compared to 2015) of domestic primary energy consumption: by 11–13% by 2025, and by 19–23% – by 2035-2050.

To this end, the consumption of petroleum products in the period between 2015 and 2050 should increase by 15–17% and that of natural gas – by 23–28%, while the consumption of coal and other solid fuels should decrease by 5% under the conservative scenario and should increase by 1.5% under the target scenario. The consumption of non-carbon energy resources (HPPs, NPPs, non-conventional renewables) should increase by 33–43%.

The resulting energy consumption structure in Russia is shown in Figure 2.

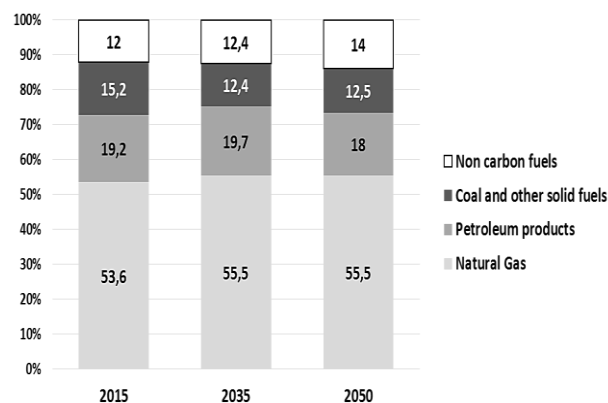


Fig. 2. Projected structure of energy consumption in Russia, %

As shown in Figure 2, natural gas will remain the dominant resource in primary energy consumption in Russia throughout the period under review: its share in the demand structure will increase from 53.6% in 2015 to 55–56% by 2050.

The share of petroleum products in the structure of primary energy consumption by 2050 under the conservative scenario will decrease to 18.5% (as compared to 19.2% in 2015), and, under the target scenario, to 18%, while the share of coal and other solid fuels will decrease from 15% to 12–12.5%.

The share of non-carbon energy sources in domestic consumption will remain at about 12% until 2035 and only by 2050 will it increase to 13.5–14%.

The results of the study show that after 2035 the consumption of energy resources in the Asian regions of the country will grow faster than before. Over the period under review (2015–2050) energy consumption in the Asian regions may increase by 28–35% (in the country as a whole – by 19–23%).

At present, Russia enjoys the status of the world's largest exporter of energy resources, the sales volume of which is slightly less (by 3%) than their domestic consumption in the country.

Within the given timeframe, export volumes and structure will be mainly determined by the factors of economic feasibility and will depend not only on fuel prices in the international energy markets but also on prices and production volumes of Russian producers.

At the same time, the political component will also play an important role.

The dynamics of international fuel prices assumed for modelled calculations is given in Table 2, while that of domestic prices is given in Table 3.

Table 2. Projection of fuel prices* in international markets

Indicator	2015	Projection		
		2025	2035	2050
Oil, USD per barrel	45	50-65	50-65	65-80
Natural gas, USD per 1,000 m ³				
Europe	240	250-290	250-290	300-350
Countries of Northeast Asia:				
China (pipeline gas)	250	275-290	300-345	330-380
Japan (LNG)	310	340-380	380-450	430-500
Steam coal, USD per ton	63	65-70	60-75	60-80

Note: *reported in constant 2015 prices.

Source: documents of strategic development of the Russian energy sector to 2035 and authors' estimates.

Table 3. Projection of fuel prices* in Russian markets

Indicator	2015	Projection		
		2025	2035	2050
European market				
Natural gas, USD per 1,000 m ³	90-105	120-130	120-150	125-185
Steam coal, USD per tce	45-50	50-60	50-75	65-80
Asian market				
Natural gas, USD per 1,000 m ³	95-100	120-135	145-170	170-200
Steam coal, USD per tce	35-45	50-60	50-60	55-65

Note: *reported in constant 2015 prices.

Source: documents of strategic development of the Russian energy sector to 2035 and authors' estimates.

The projected exports of Russian energy resources that we arrived at given international and domestic prices of fuel and energy supplies as assumed in calculations are shown in Table 4.

Table 4. Projection of exports of Russia's energy resources

Indicator	2015	Projection		
		2025	2035	2050
Exports, total, mln. tce/%,	925	1,050-1,090	1,010-1,070	915-1,060
Inclusive of the following:	100	114-118	96-98	87-97
Oil and petroleum products, mln. tons	406	377-390	321-338	276-312
Natural gas, bln. m ³	204	290-294	308-323	272-327
Coal, mln. tce	115	180-194	200-215	200-230
Electricity (balance), billion kWh	7	21-22	22-28	62-67

It follows from the above that in 10 years (i.e., by 2025) the exports of Russian energy resources will increase by 14–18%, and then decline by 2050: under the conservative scenario – by 13%, under the target scenario – by 3%.

As is evidenced from Figure 3, oil exports will dominate in the structure of energy resources exports from Russia in the period under review, while its share in the structure of exports will gradually decrease: from 62% in 2015 to 45% by 2035 and to 42–43% by 2050.

Within the given timeframe, the European export destinations will remain the dominant ones for Russia, but their share in total exports will decrease and by 2050 it will amount to 55–62% (as compared to 80% in 2015).

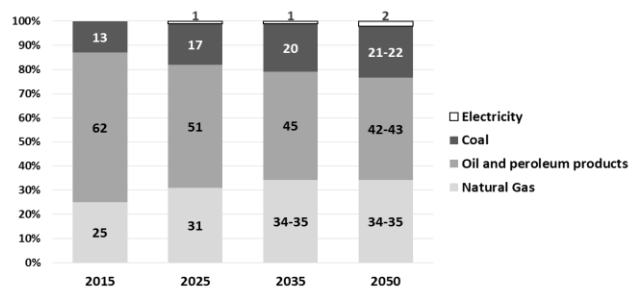


Fig. 3. Structure of Russian energy resources exports, %

The decline in the share of oil exports will be substituted mainly with natural gas and coal. At the same time, the share of natural gas in the structure of exports will increase from 25% in 2015 to 34–35% by 2035 and will remain at this level until 2050.

The share of coal will grow from 13% in 2015 to 21–22% by 2050.

Figure 4 shows the structure of Russian energy resources exports by export destinations.

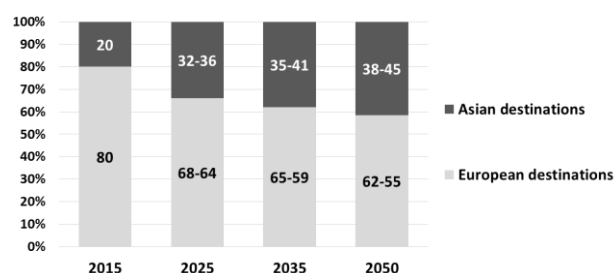


Fig. 4. Structure of Russian energy resources exports by destinations

At the same time, the availability of economically viable energy resources in the Asian regions of Russia and the growing demand for them in the NEA countries make Asian destinations of energy exports from Russia more promising. It is estimated that by 2050 the share of energy exports to Asian destinations in total energy exports may increase to 38–45% as compared to 20% in 2015.

The volume of energy resources production in Russia resulting from our modelled calculations is shown in Table 5.

Table 5. Energy production in Russia to 2050

Indicator	2015*	Projection		
		2025	2035	2050
Production, total, mln tce/%, inclusive	1886 / 100	2,117-2,173 / 112-115	2,170-2,257 / 115-120	2,094-2,284 / 111-121
of:				
Oil and gas condensate, mln. tons	534	526-542	428-502	428-466
Natural gas, bln. m ³	635	784-799	855-878	832 - 907
Coal, mln. tons	374	447-470	477-510	485 - 539
Other solid fuels, mln. tce	32	32	38	44
Hydropower, TW-h	170	207-208	215-221	251-260
Nuclear power, TW-h	195	222	256-263	330-361
Non-conventional renewable energy, TW-h	2.4	9-10	28-36	55-60

Note: *2015=100%

Our studies attest to the need to increase energy production in Russia by 11-21% by 2050 (as compared to 2015) to meet the country's projected domestic demand for energy resources and their exports.

It is estimated that oil and gas condensate production in the country will decrease by 2050 (as compared to 2015) by 20% under the conservative scenario and by 13% under the target scenario.

Natural gas production will increase (as compared to 2015) by 35–38% by 2035 and by 31–43% by 2050.

Table 6 shows the share of the Asian regions in the projected energy resources production in Russia.

Table 6. Share of Asian regions in energy resources extraction (production) in the country, %

Indicator	2015	Projection		
		2025	2035	2050
Energy, total, including:	79	82	83	81
Oil and gas condensate	70	73	75-84	78-79
Natural gas	92,5	93-94	94-95	89-87
Coal	94	96-97	96-97	97-98

Note: *2015=100%

According to the authors' estimates, by 2050 the Asian regions of Russia will account for 78–79% of oil production in the country (70% in 2015), 87–89% of gas production (92.5% in 2015), and 97–98% of coal production (94% in 2015).

Table 7 shows the dynamics of energy resources production in the Asian regions of Russia.

Table 7. Energy resources production in the Asian regions of Russia

Indicator	2015	Projection		
		2025	2035	2050
Production, total, mln tce/%, inclusive of:	1,493 100*	1,736-1,790 105-112	1,812-1,890 121-127	1,708-1,848 114-124
Oil and gas condensate, mln. tons	375	383-397	359-377	333-366
Natural gas, bln. m ³	588	734-748	807-832	741-787
Coal, mln. tons	351	431-454	460-494	473-528
Other solid fuels, mln. tce	9	8	8,6	9,4
Hydropower, TW·h	108	137	145-148	170-175
Nuclear power, TW·h	0,2	0,5	0,5	0,6
Non-conventional renewable energy, TW·h	0,8	2,5-3,8	9-13	18-20

Note: *2015=100%;

At present, the main oil production area is Western Siberia. It is projected that oil production in Western Siberia (as compared to 2015) may decline by 25% (by 80 million tons) under the conservative scenario by 2050, and by 17% (by 55 million tons) under the target scenario.

In the period under review, East Siberian and Russian Far Eastern fields may make a significant contribution to oil production, with production growth by 2050 to 55–60 million tons in East Siberia and 45-48 million tons in the Russian Far East.

Western Siberia where gas production may grow by 2035 and then decline by 2050 remains the main gas-producing region within the given time frame.

Eastern Siberia and the Russian Far East will become promising gas production regions in the period under review. Given the favourable market conditions in the Asian export destinations, gas production in Eastern Siberia will increase to 50–65 billion cubic meters by 2050 and to 72–77 billion cubic meters in the Russian Far East.

Coal production in Western Siberia is projected to grow by 2050 to 275–315 million tons (as compared to 215 million tons in 2015).

Significant growth in coal production will be provided by Eastern Siberia and the Russian Far East. According to the authors' estimates, coal production may grow by 30–42% by 2050 in Eastern Siberia, while increasing 1.8–1.9 times in the Russian Far East.

Production of non-carbon electric power sources in the Asian regions of the country (nuclear power, hydropower, non-conventional renewable sources) will increase by 23–28% by 2035 and by 34–39% by 2050.

That having been said, their share in the country's energy production will increase insignificantly: from 6.1% in 2015 to 6.3% by 2035 and to 7.5% by 2050.

Figure 5 shows the projected dynamics of energy resources exports from the Asian regions of Russia.

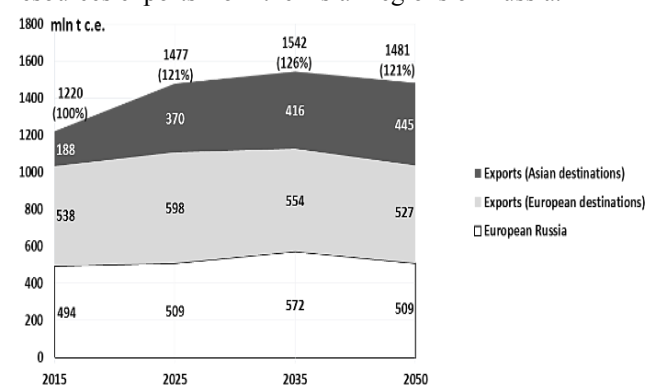


Fig. 5. Exports of energy resources from the Asian regions (target scenario)

In 2015, 1,220 million tce of energy resources (or 82% of their total production) were exported from the Asian regions of Russia, 41% of which were for the needs of the European part of the country and 59% were for exports.

According to the authors' estimates, the exports of energy resources from the Asian regions will increase by 21–26% by 2035, and then will decrease by 4–8% by 2050.

Figure 6 shows how the percentage ratio with respect to the destinations of energy resources exports from the Asian regions of Russia may change:

- the share of energy resources exported to the European part of the country in total exports will decrease and by 2050 will amount to 37–34% (as compared to 41% in 2015).
- the share of Asian energy resources exported to European destinations will decrease from 44% in 2015 to 39–36% by 2050.
- the share of Asian energy resources exported to Asian destinations will increase from 15% in 2015 to 24–30% by 2050.

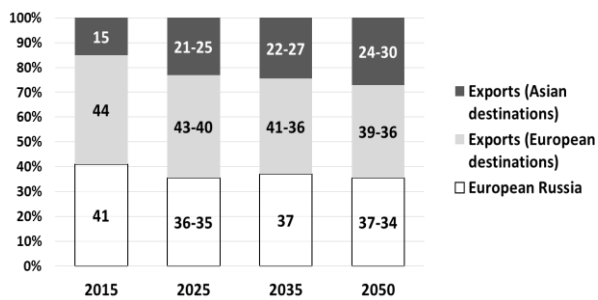


Fig. 6. Structure (by destination) of energy resources exports from the Asian regions

4 Conclusion

1. Under the considered scenarios of Russia's economic development, energy consumption in the country (in the period from 2015 to 2050) should increase by 19–23%, with energy consumption in Asian regions increasing by 28–35%. As a result, the share of Asian regions in the total energy consumption of the country will increase from 29% in 2015 to 31–32% by 2050.

2. Within the timeframe under review the Asian regions will still remain the main suppliers of energy resources, both to the domestic market of the country and for exports.

3. According to the authors' estimates, the exports of energy resources from Asian regions may increase by 21–26% by 2035 and then decrease by 4–8% by 2050.

At the same time, the proportion of exports of energy originating from Asia will also change in terms of their destinations:

- exports to European Russia will decrease from 41% in 2015 to 34–37% by 2050;

- exports to European destinations will decrease from 44% to 36–39%;

- exports to Asian destinations (Northeast Asian countries) will increase from 15% to 24–30%.

4. To meet domestic demand for energy resources and their exports, energy production in Russia's Asian regions should grow by 21–27% by 2035 (as compared to 2015), and then decline by 6–2% by 2050.

By 2050, Asian regions are expected to account for 78–79% of the country's oil production (70% in 2015), 87–89% of natural gas production (92.5% in 2015), 97–98% of coal (94% in 2015), 67–68% of electricity produced by HPPs (64% in 2015).

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