Structural changes in energy balances in the eastern regions of Russia Considering energy cooperation with NEA countries

A.D. Sokolov, S.Yu.Muzychuk, R.I.Muzychuk

Abstract. **The paper deals with methodological issues concerning making perspective energy balances. Their practical application for the eastern regions of Russia is shown. Structural changes that can occur in the course of energy development in these regions are estimated.**
Key words: **eastern regions, energy consumption, fuel and energy complex, energy resources, energy balance, structure, energy efficiency.**

Currently the economy of Russia and particularly the economy of Russia's eastern regions (East Siberia and the Far East) are characterized by high energy intensity, which negatively affects its energy efficiency. The Decree of the President of the Russian Federation No.889 of June 4 2008 "On some measures to enhance energy and environmental efficiency of the Russian economy" stated the goal to decrease the energy-GDP ratio of the Russian Federation by 2020 by no less than 40% against 2007 and to provide rational and environmentally sound utilization of energy resources [1]. The issues of energy efficiency enhancement were also paid attention to in the anti-crisis program of the RF Government, "The primary modernization task of the Government is to change the existing model of economic growth. The "oil-based" growth should be replaced by the growth on the basis of innovations. The most important innovation processes including enhancement of energy efficiency of the economy will be supported" [2].

A most important priority of the Energy strategy of Russia for the period up to 2030 that was approved by the Decree of the RF Government No.1715-p of November 13, 2009 is enhancement of energy efficiency of the Russian economy, namely: reduction of specific costs in energy production and utilization through rationalization of energy consumption, application of energy saving technologies and equipment and reduction of losses when producing, processing, transporting and selling energy products [3].

Increase of energy efficiency of the economy determines the urgency of rationalization in production and utilization of energy resources nationally and regionally. *This problem can not be solved without forecasting the development of fuel and energy complex (FEC) and energy balances* [4] that give more complete information on situation in the regional FEC and integrate the production and consumption balances for individual types of energy carriers.

Significance of making up the forecasted energy balances was reflected in the Energy strategy of Russia for the period up to 2030, which clearly states that one of the main targets of the national energy policy is a rational energy balance [3].

Energy Systems Institute, SB of RAS, has developed a special software package to generate a regional energy balance.

Energy balance is made up according to the international forms assumed in the countries of the Organization for Economic Cooperation and Development (OECD) [5] in either tce or toe. Further these forms are supposed to be implemented in the state statistics of Russia.

Calculated energy balance represents an analytical table that contains a list of energy resources and main indices that characterize their sources and directions of utilization.

The obtained forecasted energy balances are analyzed and then used to estimate the efficiency of using energy resources at the stages of their production, conversion and final consumption. Besides, their cost estimations are made that can help reveal various structural and price disproportions in the regional FEC development.

Energy balance serves as the main information basis for calculation of energy consumption and determination of energy efficiency indices (energy -, electricity-, and heat – GRP ratio) and coefficients of energy utilization efficiency (CEUE) in final consumption and at energy

A.D. Sokolov, S.Yu.Muzychuk, R.I.Muzychuk Energy Systems Institute SB of RAS Irkutsk, Russia (e-mail: sokolov@isem.sei.irk.ru, muz@isem.sei.irk.ru, rmuz@isem.sei.irk.ru).

facilities (at thermal power plants, boiler plants and in conversion processes).

The above coefficients can be used to reveal the trends in energy efficiency of the economy and identify possible reserves for energy conservation.

Along with the energy efficiency indices that are calculated on the basis of energy balance some other indices are applied to determine a more preferable strategy. These are calculated tariffs for electricity and heat, indices of socio-economic and budget efficiency, and indices of environmental and energy security.

Integrated application of these indices makes it possible to choose from a variety of regional FEC development scenarios the most rational one with a sufficiently high degree of reliability.

The study of FEC development and solution to the energy balance rationalization problem vary depending on the considered territory. For example Russia's eastern regions (East Siberia and the Far East) are traditionally resource redundant regions whereas most European regions are resource deficient, which determines the production structure of energy balance. Besides the structure of energy resources consumption in the eastern regions is dominated by coal (70-75%) and that of the European regions – by natural gas (above 60%) which affects the consumption structure of energy balance.

Energy balances are divided into reported and forecasted according to the purposes. Reported energy balances are based on information from statistic reports.

The reported energy balance of the eastern regions for 2008 is presented in Table 1.

Balance item	Coal and products of processing	Wood and other fuel kinds	Oil and oil products	Natural gas and products of processing	RES*	Electricity	Heat	Total
Production of energy resources	70.2	4.0	20.3	16.1	11.8			122.4
Import	3.3		37.8					41.1
Export	-21.1		-39.5	-5.7		-2.3		-68.6
Primary energy resources, total	52.4	4.0	18.4	10.4	11.8	-2.3		94.7
Converted energy	-47.0	-2.0	-4.8	-8.0	-11.8	20.0	20.9	-32.7
Electricity and heat production by TPPs	-37.8	-1.4	-1.5	-6.0		11.5	13.0	-22.2
Electricity production by RES					-11.8	11.8		
Heat production by boiler plants	-9.2	-0.6	-2.9	-1.4			10.1	-4.0
Oil refining			-0.2					-0.2
Auxiliaries and losses			-0.2	-0.6		-3.3	-2.2	-6.3
Final consumption	-5.4	-2.0	-13.6	-2.4		-17.7	-20.9	-62.0

TABLE 1. ENERGY BALANCE OF RUSSIA'S EASTERN REGIONS, MILLION TCE (AS OF 2008)

*Renewable energy sources (hydro, nuclear, wind, geothermal energy, etc.)

Analysis of the reported energy balance allows the conclusions on:

- sufficiency of local energy resources in the eastern regions;
- possibility to supply energy resources outside the regions;
- possibility to create new energy intensive productions on the basis of energy resources available in the eastern regions;
- possibility to utilize renewable energy resources in the regions;

Production of primary energy resources in the eastern regions can fully meet local demand and provide export supplies, however, because of technical and economic conditions the

regions import coal, oil and oil products from Western Siberia.

The shares of heat (35%), electricity (28%) and oil products (21%) dominate the structure of final energy consumption.

Improvement of energy balance structure should facilitate solving the main problems in FEC development of the eastern regions.

The main problems and priorities of FEC development in East Siberia and the Far East include:

- Enhancement of energy utilization efficiency which in these regions is 20-30% lower than the average in Russia and essentially lower than in developed countries. Energy conservation potential in all spheres of the economy in the eastern regions makes up 25-30 million tce (25-30 % of the total energy consumption).
- In order to improve environmental situation in some areas of East Siberia and the Far East and provide reliable fuel supply to consumers the existing fuel balance structure should be improved by converting consumers in the eastern regions to gas.
- An urgent national need for new sources of oil and gas production, coal-dominated fuel balance in the eastern regions, presence of a large number of potential consumers of hydrocarbons and products of their processing and pressing environmental problems in some industrial centers make fastest wide-scale development of oil and gas resources in Krasnoyarsk Territory, Irkutsk Region, Sakha Republic (Yakutia) and Sakhalin shelf one of the most urgent economic problems not only in the eastern regions but in the entire country.
- Increase of economic efficiency and competitiveness of east-siberian and far-eastern coals in the internal and external fuel markets can be provided by integrated processing and utilization of coals. Processing of local coals can be of great social significance, since washed coal should first of all be used by residential consumers.
- Orientation towards development of regional and local fields should become the most important factor in the improvement of fuel supply reliability in the regions. This will make it possible to increase energy independence of the regions and provide sufficiently high reliability level of fuel supply to consumers.
- The extent to which energy generation equipment is worn and outdated causes the need for restructuring of power industry and heat economy by the improvement of technology at thermal and boiler power plants; rationalization of fuel consumption structure; utilization of renewable energy sources in the amount required for reliable power supply to consumers.
- All-round consideration is necessary for the problems of energy supply to northern and isolated consumers in East Siberia and the Far East.
- An important direction of increasing reliability of energy supply to consumers in East Siberia and the Far East is rational energy cooperation with NEA countries (Japan, Korea, China).

Table 5 presents the required development of FEC that makes it possible to solve the majority of key problems, meet internal demands of the regions (Table 2), provide export supplies (Table 3) and achieve the targeted growth rate of GRP of the eastern regions of Russia (Table 4).

TABLE 2. CONSUMPTION OF ENERGY RESOURCES IN RUSSIA'S EASTERN REGIONS

Energy resource	Year		
	2008	2020	2030
Electricity, billion kWh	178	246-276	310-360
Heat, million Gcal	182	214-227	214-227
Fuel , million tce	70	94-128	117-148
Motor fuel, million tce	10	12-14	16-19

TABLE 3. EXPORT OF ENERGY RESOURCES FROM RUSSIA'S EASTERN REGIONS

Energy resource	Year		
	2008	2020	2030
Electricity, billion kWh	0.2	7-63	7-63
Oil, million t	13	38-51	49-88
Natural gas, billion m^3	-	42-89	70-109
Coal, million t	15	39-48	46-49

TABLE 4. GROSS REGIONAL PRODUCT* OF RUSSIA'S EASTERN REGIONS

Index	Year			
	2007	2008**	2020	2030
GRP, billion rub.	2736	2905	5600-6656	8220-10050
Growth rate of GRP, %	100	106	105-107	108-109

*in 2007 prices; **An estimate

Perspective energy balances for the eastern regions have been made up in accordance with the studies performed at Melentiev Energy Systems Institute in 2008-2009 (Tables 6, 7).

By the years 2020-2030 the energy balance structure in the eastern regions will change considerably with an essential increase in the share of hydrocarbons (oil and natural gas) from regional production. Whereas in 2008 the total share of oil and natural gas was 31% in the production structure of energy resources in the eastern regions, in 2020-2030 it will reach 62-64% (Fig. 1).

TABLE 5. PRODUCTION OF ENERGY RESOURCES IN RUSSIA'S EASTERN REGIONS

Energy resource	Year		
	2008	2020	2030
Electricity, billion kWh	195	280-368	381-483
Heat, million Gcal	182	214-227	245-267
Coal, million t	118	177-221	224-274
Oil, million t	14	61-78	71-101
Natural gas, billion m^3	13	68-129	91-173
Oil products, million t	27	52-61	55-64

Balance item	Coal and products of processing	Wood and other fuel kinds	Oil and oil products	Natural gas and products of processing	RES	Electricity	Heat	Total
Production of energy resources	139.3	3.2	110.8	154.7	18.0			426
Import	2.3		49.1					51.4
Export	-59.8		-136.3	-111.7		-8.5		-316.3
Primary energy resources, total	81.8	3.2	23.6	43.0	18.0	-8.5		161.1
Converted energy	-75.8	-1.9	-2.4	-23.1	-18.0	40.8	28.2	-52.2
Electricity and heat production by TPPs	-66.4	-0.8	-0.5	-16.8		27.6	17.4	-39.5
Electricity production by RES					-18.0	18		
Heat production by boiler plants	-9.4	-1.1	-0.7	-6.3			13.15	-4.4
Oil refining			-0.6					-0.6
Auxiliaries and losses			-0.6			-4.8	-2.3	-7.7
Final consumption	-6.0	-1.3	-21.2	-19.9		-32.3	-28.2	-108.9

TABLE 6. ENERGY BALANCE OF RUSSIA'S EASTERN REGIONS, MILLION TCE (AS OF 2020)*
* Strategic (maximum) scenario

The coal share in production structure of energy resources will decrease from 56% in 2008 to 33% in 2020 and to 31% in 2030. The share of renewable energy resources, including hydro energy, will fall from 8% in 2008 to 4% in 2020-2030.

In 2020-2030 the production part of the energy balance in the eastern regions will continue increasing (as in 2008) by delivery of oil from West Siberia and small volumes of coal. Their share, however, will gradually decrease (from 27% in 2008 to 11% in 2020 and to 10% in 2030).

By the years 2020-2030 the export structure of energy resources from the eastern regions will change essentially: the coal share will decrease and the share of hydrocarbons will increase. The total share of oil, oil products and natural gas in export will rise from 37% in 2008 to 76% in 2020 and to 80% in 2030 (Fig. 2).

Despite the sizable growth of electricity in absolute figures (by more than fivefold for the

years 2008-2030) its share in the structure of exported energy resources will remain at a 3% level. This fact is explained by the enormous rise of the total volumes of energy resources exported from the eastern regions, namely from 67.5 million tce to 322.8 million tce in 2020 and to 399.5 million tce in 2030.

Balance item	Coal and products of process-ing	Wood and other fuel kinds	Oil and oil products	Natural gas and products of processing	RES	Electrici-ty	Heat	Total
Energy resources production	160.8	3.1	169.9	170.4	18.7			522,9
Import	1.8		56.6					58,4
Export	-62.3		-197.6	-121.3		-11.8		-393
Primary energy resources, total	100.3	3.1	28.9	49.1	18.7	-11.8		188,3
Converted energy	-91.9	-1.8	-1.6	-26.1	-18.7	54.7	33.6	-51,8
Electricity and heat production by TPPs	-81.1	-0.9	-0.3	-18.0		40.7	20.5	-39,1
Electricity production by RES					-18.7	18.7		
Heat production by boiler plants	-10.8	-0.9	-0.5	-8.1			15.4	-4,9
Oil refining			-0.4					-0,4
Auxiliaries and losses			-0.4			-4.7	-2.3	-7,4
Final consumption	-8.4	-1.3	-27.3	-23.0		-42.9	-33.6	-136,5

TABLE 7. ENERGY BALANCE OF RUSSIA'S EASTERN REGIONS, MILLION TCE (AS OF 2030)*
*Strategic (maximum) scenario

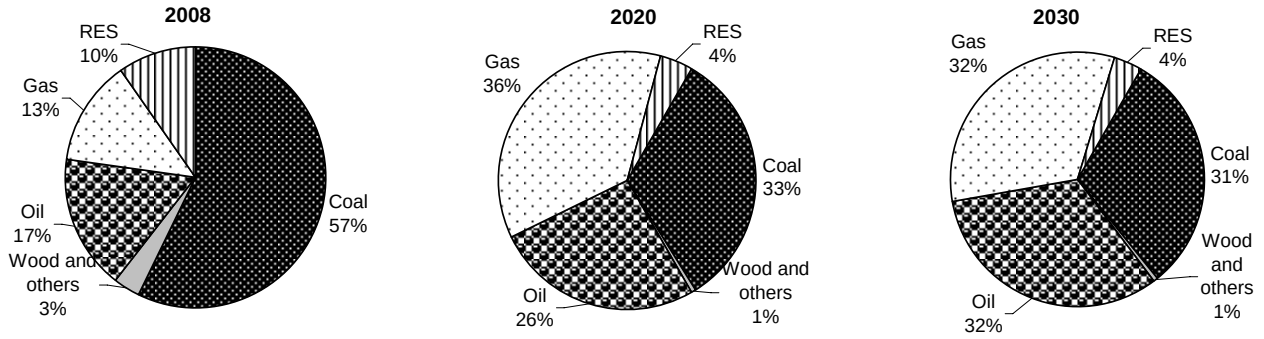

Fig. 1. Production structure of primary energy resources

Electricity and heat production by power and boiler plants in the eastern regions requires large amounts of energy resources. In 2008, for example, to produce 47.7 million tce of electricity and heat 72.6 million tce of energy resources (including renewable natural energy resources) were used, the coal share in the resources made up about 65%. This trend will remain valid for the future. In 2020 production of 75.3 million tce of electricity and heat will call for 112.9 million tce of energy resources (the coal share will be about 61%), in 2030 to produce 94.9 million tce of energy carriers 141.7 million tce of energy resources will be consumed (the coal share will be about 67%). The coal share in electricity and heat production will somewhat increase by 2030 owing to commissioning of export coal-fired power plants at full capacity.

In 2020-2030 the final consumption structure of energy resources will also change (Fig. 3).

In comparison with 2008 the natural gas share in the final consumption structure of energy resources by 2020-2030 will rise from 4% to 17-18%. The share of oil products will remain at a 20% level. The heat share will fall from 35% in 2008 to 26% in 2020 and to 24% in 2030. The electricity share will rise negligibly – from 28% in 2008 to 32% in 2030. The shares of coal, wood and other fuel kinds will somewhat decrease.

These structural changes will have a favorable effect on environmental situation in the eastern regions.

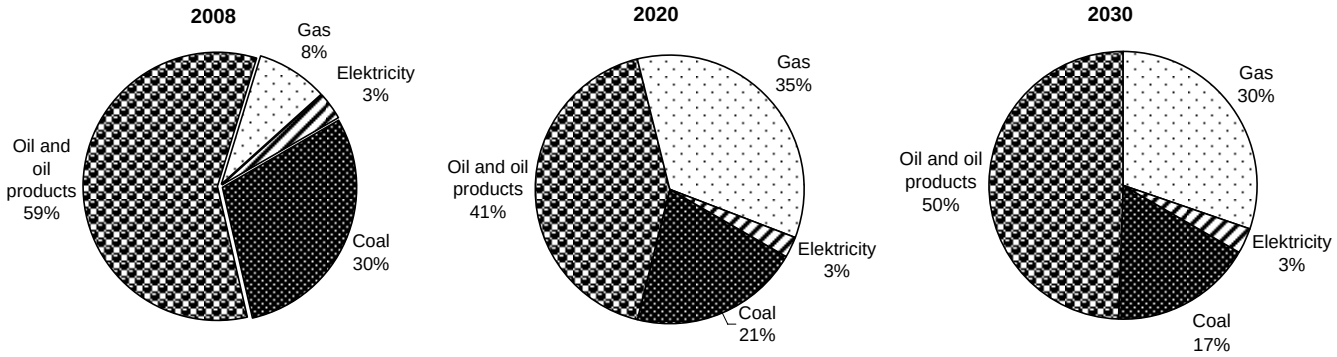

Fig. 2. Structure of exported energy resources

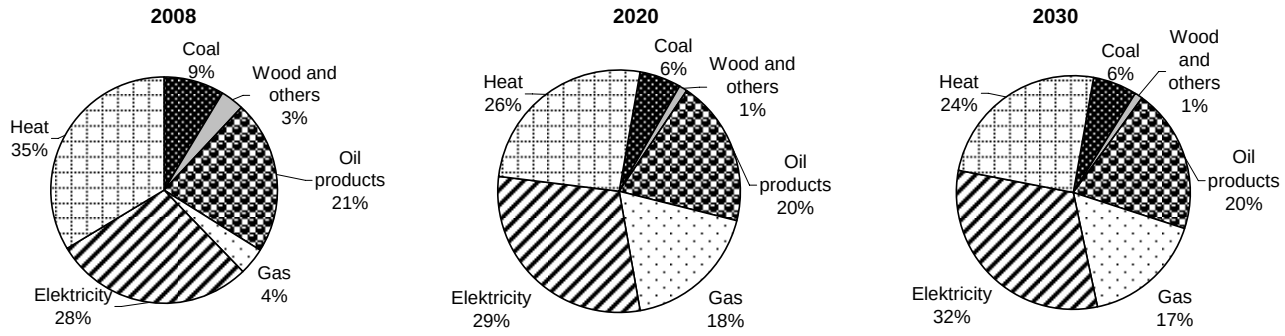

Fig. 3. Final consumption structure of energy resources

Thus, the large-scale development of hydrocarbon resources in the eastern regions will lead to changes in the production structure of the energy balance and involve changes in the consumption structure as well, namely the structure of export and final consumption. Changes in the energy balance structure will contribute to considerable enhancement of energy efficiency of the economy in the eastern regions (decrease in energy, electricity and heat -GRP ratio, CEUE).

The energy-GRP ratio in the eastern regions is much higher than the average indices for Russia (Table 8), which indicates the formed high energy intensive structure of industrial production, as well as the low efficiency of regional energy conservation policy pursued.

The summary energy balances were used as a base to calculate energy efficiency of the economy of the eastern regions.

The energy efficiency indices and the coefficients of energy utilization efficiency tend to decrease, which characterizes sustainable economic development of the eastern regions at considerable growth of energy consumption for the time horizon up to 2030.

TABLE 8. INDICES OF ENERGY EFFICIENCY OF RUSSIA'S EASTERN REGIONS

Index	Year			
	Russia	Eastern regions		
	2008		2020	2030
Energy- GRP ratio*, kg ce/thousand rub.	20.5	31.8	23.2	19.0
Electricity-GRP ratio, kWh/thousand rub.	26.9	48.8	39.0	34.7
Heat- GRP ratio, kcal/rub.	29.4	51.0	29.2	23.1
CEUE in final consumption, %	72.8	67.1	70.3	71.4
CEUE in conversion processes, %	57.8	57.3	59.8	61.7
CEUE at power plants, %	55.5	54.4	56.7	58.6
CEUE at boiler plants котельных, %	83.0	76.6	77.9	81.3

*In 2007 prices

The developed software tools were applied to study perspective development of different RF entities in the East of Russia (Irkutsk, Amur and Sakhalin Regions, Burayt Republic [7], Sakha Republic (Yakutia) [8], Khabarovsk Territory [9], Chukot Autonomous District), and also to elaborate the strategy of FEC development in East Siberia and the Far East up to 2030 and the draft program of FEC development in East Siberia and the Far East up to 2020. Its results were included in the documents of the Energy Strategy for the period up to 2030 that was approved by the Decree of the Government of the RF No. 1715-r of November 13, 2009.

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BIOGRAFPHIES

Alexsandre D. Sokolov is Head of laboratory "Problems of FEC development in Siberia and the Far East" at Energy Systems Institute SB of RAS, Prof. His research interests are FEC development in the Asian part of Russia, modeling of coal industry development.

Svetlana Y. Muzychuk is a principal researcher of laboratory "Problems of FEC development in Siberia and the Far East" at Energy Systems Institute SB of RAS, Dr. Her main research interests are concern forecasting of regional FEC development and drawing up the forecasting energy balances for the regions of Siberia and the Far East.

Roman I. Muzychuk is Engineer of laboratory "Problems of FEC development in Siberia and the Far East" at Energy Systems Institute SB of RAS. Research interests: existing computing methods and tools for forecasting regions fuel energy complexes, their creation and development.