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Article

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International Journal of Energy Economics and Policy

Provided in Cooperation with:
International Journal of Energy Economics and Policy (IJEEP)

Reference: Osinovskaya, Irina Vladimirovna (2017). System aspects of fuel and energy balance formation. In: International Journal of Energy Economics and Policy 7 (5), S. 271 - 278.

International Journal of Energy Economics and Policy

ISSN: 2146-4553

available at http: www.econjournals.com

International Journal of Energy Economics and Policy, 2017, 7(5), 271-278.

System Aspects of Fuel and Energy Balance Formation

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ABSTRACT

This article reveals the importance of the fuel and energy balance (FEB) for ensuring the country's energy security. The role of the fuel and energy complex (FEC) in the Russian economy is shown. FEB is considered as a possible efficient tool for managing the development of the FEC and, as a consequence, ensuring the country's energy security. The necessity to develop the methodological foundations of the FEB formation is substantiated. Proposals have been made concerning the expediency of building the process of forming the FEB on the basis of systemic contours. The author's interpretation of the term "systemic contour" is disclosed in the context of solving the issues on the formation of FEB. It is proposed to single out several major systemic outlines that reflect the situation of the world's energy and political systems, the social, economic, political and energy systems of the country, as well as in the FEC and other subsystems. Particular attention is paid to the issues of information support for the formation of FEB, taking into account the spatial coverage of the subsystems included in the consolidated FEB of the country. The need for attention on the part of the state to address the issue of forming unified information and analytical space and an early warning system is underlined. The emphasis is placed on the fact that it is these information systems that will allow timely monitoring of the changes in the subsystems of the FEC, and also taking appropriate proactive measures to stabilize the situation in the short and long term.

Keywords: Fuel and Energy Balance, Complex, Formation, System, State, Information, Strategy, Energy Security
JEL Classifications: L10, L94, L71

1. INTRODUCTION

The fuel and energy balance (FEB) is a balanced system of quantitative characteristics that characterize the state and level of development of the fuel and energy complex (FEC) at a certain point in time.

Stable and progressive development of the FEC contributes to the implementation of strategic goals at the state level regarding the preservation of the country's energy security. The level of economic development of the country today still depends on the level of the FEC development. According to A. Novak, despite the sanctions and reduction of prices for the main energy carriers, all fuel and energy industries worked in 2016 steadily and improved their performance. The total inflow of investments into the TEC amounted to 3.7 trillion rubles, growth - about 6%. All power engineering developed ahead of the economy. For the first time in many years, the commissioning of new fields began (Results of the FEC in 2016, 2017).

Today the FEC is one of the most stable operating production complexes of the Russian economy. It accounts for about 30% of Russia's GDP, 50% of the country's tax revenue, and 30% of exports. The structure of the FEC is shown in Figure 1.

Oil production with condensate in Russia and the world for the period from 1970 to 2015 is presented in Table 1 (Eder et al., 2016).

In 2015 Russia reached the highest level of oil production in the newest history of the country - 534 million tons, or 12.2% of the world production. However, it is only 93% of the oil production in 1987. The stable trend in the change in the structure of oil production in Russia is an increase in the share of gas condensate production, which is associated with an active involvement of high-condensate gas in the Western Siberia. And such trends are observed in all subsystems of the Russian FEC, which will directly lead to a gradual change in the structure of the energy balance in the prospective period.

Figure 1: Structure of the fuel and energy complex

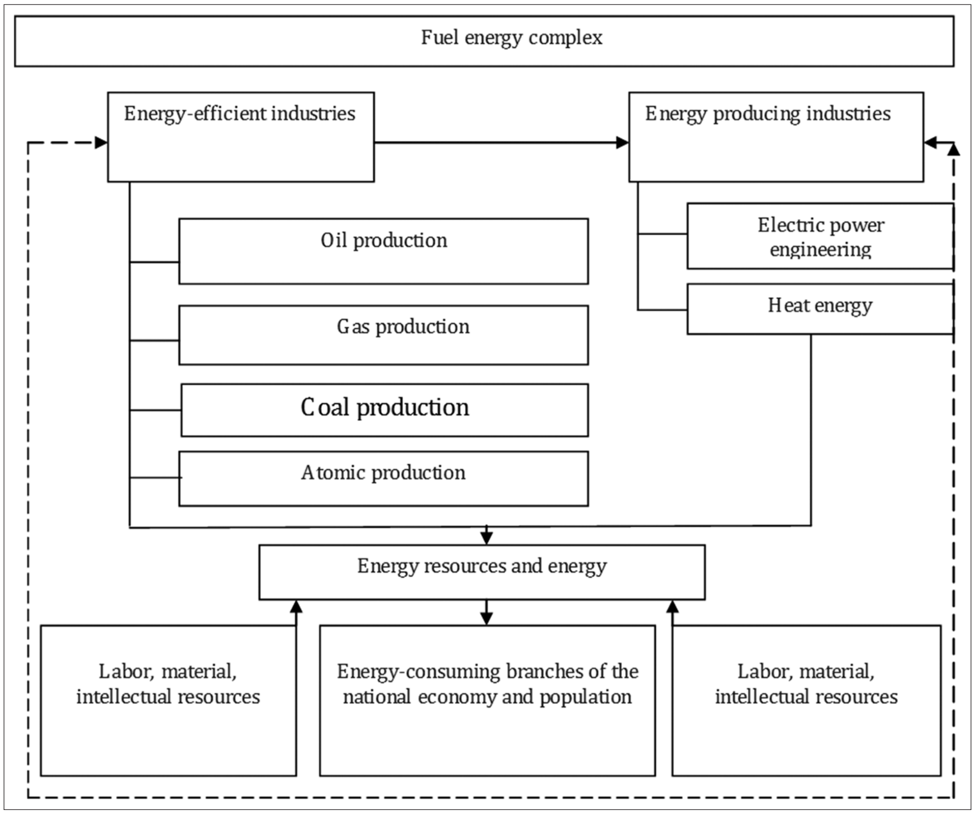


Table 1: Oil production with condensate in Russia and the world (1970-2015)

Year	In the world	USSR/CIS		RSFSR/Russia		OPEC		Oil prices on the world market, USD/bbl.	
		Total mt.	Share in the world, %	Total mt.	Share in the world,%	Total mt.	Share in the world, %	Urals	Brent
1	2	3	4	5	6	7	8	9	10
1970	2.355	353	15.0	285	12.1	1132	48.0	-	-
1980	3.088	603	19.5	547	17.7	1287	41.7	38.3	39.8
1985	2.792	608	21.8	542	19.4	772	27.6	25.9	27.6
1990	3.168	570	18.0	516	16.3	1159	36.6	20.3	21.0
1995	3.278	355	10.8	307	9.4	1317	40.2	16.4	16.2
2000	3.618	396	10.6	323	8.9	1511	41.8	27.4	28.3
2005	3.938	580	14.8	470	12.1	1691	42.9	50.2	54.6
2010	3.979	663	17.0	505	13.1	1671	42.0	77.9	79.6
2011	4.012	665	16.6	511	12.7	1711	42.6	108.0	110.0
2012	4.119	669	16.2	518	12.6	1782	43.3	110.6	111.7
2013	4.127	677	16.4	523	12.7	1734	42.0	107.9	108.7
2014	4.229	677	16.0	527	12.5	1733	41.0	97.6	97.8
2015	4.362	682	15.6	534	12.2	1807	41.4	51.2	53.5

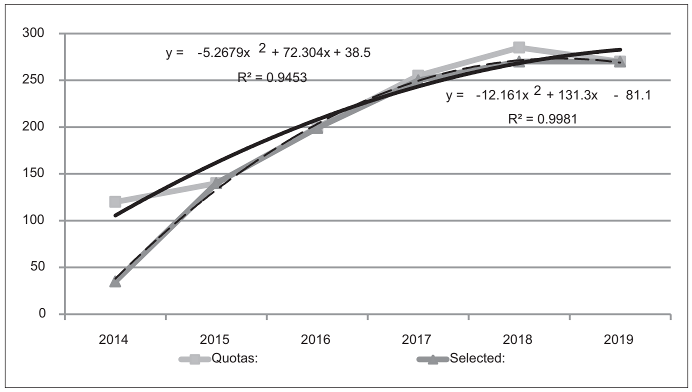
Investigating the state of the FEC for today and its impact on the structure of the energy balance, it is necessary to identify the role of alternative energy sources. Despite the fact that for many years the most part of the energy component for Russia will be based on traditional energy carriers, it is necessary to more actively solve the tasks to achieve innovative development of non-traditional energy sources. Today, the situation in the world is developing in the field of alternative energy sources, and if Russia does not follow the trend of innovative development, then there is a risk of lagging behind the leading countries in the world.

The report of the national rating agency Development of Alternative Energy in Russia notes that the electric power industry based on renewable energy sources (RES) in Russia currently does not play a significant role in the country's energy system, providing less than 1% of the total electricity generation. Nevertheless, the Government of the Russian Federation defined the main directions of the state policy, within the framework of which it is envisaged to expand the using of RES in the sphere in order to increase the energy efficiency of the electric power industry (Razvitie Alternativnoy Energetiki v Rossii (Development of Alternative Power Industry in Russia, 2016). Table 2 presents the overall results of renewable energy projects.

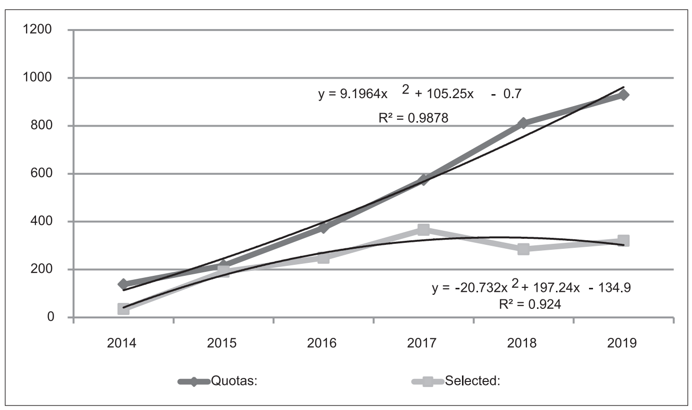
Table 2: The general results of the selection of RES

Indicator	2014	2015	Forecast				Total
			2016	2017	2018	2019	
Results of the selection of solar power plants, megawatts (MW)							
Quotas	120	140	200	255	285	270	1250
Selected	35	140	199	250	270	270	1184.2
Results of the selection of wind power plants, MW							
Quotas		51	50	200	400	500	1201
Selected		51	50	90			191
Results of the selection of small hydropower projects, MW							
Quotas	18	26	124	124	141	159	592
Selected				21		50	70.44
General results of selection of renewable energy projects, MW							
Quotas	138	217	374	574	811	929	3043
Selected	35	191	249	366	285	320	1445.64

MW



MW



The long-term forecast for the types of generating capacities is presented in Table 3. This forecast shows that in the long-term perspective, for virtually all types of generating capacity, Russia will continue to have a growth trend, and it will fit into world trends. A significant increase is projected for wind power generation (21.7%), as well as geothermal energy (11%). In Russia, the use of geothermal sources is quite a promising direction, which is due to the low cost of energy produced by geothermal power plants. The economic potential of Russia's geothermal resources is 115 million tce/year, the use of which may amount to 10% in the total energy supply balance (Alkhasov et al., 2016). Thus, the development of the country's energy within the framework of the forecast trends will lead directly to a change in the structure of the FEB in the long-term period.

The importance of the state of the FEC for the economy of the country predetermines the urgency of comprehensive consideration and development of various aspects of forming the FEB as the main tool that allows analyzing, forecasting and planning the development of energy.

The identification and analysis of the current trends in the functioning of the components of the FEB will allow to establish disproportions in the development of individual fuel and energy sectors, the need and priority of issues requiring state support. The forecasted FEBs compiled while taking into account the revealed tendencies and regularities will allow increasing the level of program-targeted development planning in the whole FEC of the country and its components, individual energy consumption subsystems. In addition, a comprehensive work on the analysis of retrospective FEBs and prospective ones will create an early warning system at the state level to identify energy threats. It should be noted that the methodological aspects of

Table 3: Forecast by types of generating capacity before 2040, gigawatts (GW)

Region/country	History		Projections					Average annual percent change, 2012-40
	2011	2012	2020	2025	2030	2035	2040	
World total installed generating capacity by region and country								
Non-OECD Europe and Eurasia	411	418	462	468	480	494	499	0.6
Russia	230	233	267	267	272	277	275	0.6
Other	180	185	194	201	208	217	225	0.7
Total Non-OECD	2.587	2.748	3.628	3.946	4.271	4.627	4.988	2.2
Total world	5.202	5.440	6.577	6.981	7.422	7.925	8.455	1.6
World installed liquids-fired generating capacity by region and country								
Non-OECD Europe and Eurasia	20	21	20	19	18	17	17	−0.8
Russia	3	3	4	4	4	3	3	−0.1
Other	17	17	16	15	15	14	13	−0.1
Total Non-OECD	161	165	178	171	164	157	151	−0.3
Total world	394	395	388	366	348	332	320	−0.8
World installed natural-gas-fired generating capacity by region and country								
Non-OECD Europe and Eurasia	147	151	165	167	176	184	187	0.8
Russia	107	109	118	113	116	119	117	0.3
Other	40	42	47	54	59	65	70	1.8
Total Non-OECD	593	624	749	822	908	1.012	1.111	2.1
Total world	1.370	1.423	1.597	1.717	1.870	2.052	2.252	1.7
World installed coal-fired generating capacity by region and country								
Non-OECD Europe and Eurasia	111	110	112	109	110	112	111	0.0
Russia	49	49	53	51	54	56	56	0.5
Other	62	61	59	58	57	55	55	−0.4
Total Non-OECD	1.076	1.146	1.344	1.358	1.359	1.376	1.406	0.7
Total world	1.715	1.782	1.947	1.947	1.936	1.946	1.970	0.4
World installed nuclear generating capacity by region and country								
Non-OECD Europe and Eurasia	40	40	53	59	58	58	58	1.3
Russia	24	24	33	38	34	33	32	1.1
Other	17	17	20	21	24	25	26	1.6
Total Non-OECD	68	69	127	164	227	265	304	5.4
Total world	369	373	414	461	532	570	602	1.7
World installed hydroelectric and other renewable generating capacity by region and country								
Non-OECD Europe and Eurasia	92	95	112	114	117	124	127	1.0
Russia	47	48	59	61	64	66	66	1.1
Other	44	47	53	53	54	57	60	0.9
Total Non-OECD	690	745	1.230	1.431	1.613	1.818	2.017	3.6
Total world	1.353	1.466	2.231	2.491	2.736	3.025	3.311	3.0
World installed wind-powered generating capacity by region and country								
Non-OECD Europe and Eurasia	2	4	8	8	8	9	9	3.4
Russia	0	0	4	4	4	4	4	21.7
Other	2	3	4	4	4	5	5	1.1
Total Non-OECD	67	89	248	306	365	423	480	6.2
Total world	220	269	569	656	750	867	961	4.7
World installed geothermal generating capacity by region and country								
Non-OECD Europe and Eurasia	0	0	2	2	2	2	2	11
Russia	0	0	2	2	2	2	2	11
Other	0	0	0	0	0	0	0	-
Total Non-OECD	4	4	11	16	26	30	34	7.8
Total world	10	10	22	28	41	46	52	5.9

Table is based on the materials of International Energy Outlook 2016 with Projections to 2040, May 2016, U.S. Energy Information Administration Office of Energy Analysis U.S. department of energy Washington, DC 20585. For the formation of the table, the «H» application was used (Appendix H contains summary tables of reference case studies for installed electric power capacity by fuel and regional electricity generation)

the analysis and the formation of forecasted FEBs are a rather complex issue, since it affects virtually all levels of management: From the FEC to industries and the state with a sufficiently wide spatial coverage.

The system vision and systematic approach to the formation of consolidated FEBs will make it possible to turn energy balances into an effective tool for managing the energy security of the country, and not as a tool for creating a statistical base that captures the values of indicators that reflect the correspondence between the arrival and consumption of fuel and energy resources, and also sources of their receipt and directions of use.

2. REVIEWING REFERENCES

Currently, the role and importance of the FEB seem to be increasing at federal and regional level. In this regard, both individual scientists and scientific society in general are starting to take an active part in solving various issues concerning the formation and use of the FEB as an efficient means of systemic management of the country's FEC and energy security. Issues regarding the formation of a FEB were studied already back in 1937 by a group of scientists including Weitz et al. (1937). A significant contribution to the systemization of knowledge on the formation of the FEB was made by S.D. Feld. In his work, he presented a methodology for the formation of a unified energy balance (Feld, 1964).

Some methodical issues regarding the accounting of non-conventional sources of hydrocarbons in the prospective FEB are regarded in the work by Alymov and Ilyinsky (2012). The FEB is regarded as a tool for analysis, forecasting and indicative planning of power industry development in works by Bashmakov (2007). Information assurance in the formation of the FEB is presented in works by Belova and Litvak (2012).

Strategic aspects of power industry development and their interrelation with the FEB are presented in a collective scientific work by Bushuev et al. (2016). General issues of the systems and systemic research theory are considered in works by Volkova and Denisov (2006), Voskoboynikov (2013). Methodical basis for forecasting including the one based on the systemic approach which can be applied in FEB forecasting is presented in works by Andronova et al. (2008), Makarov (2010) and Lyubimova (2010).

Foreign literature quite often covers issues regarding the development of Russia's FEC and its impact on the country's energy security taking into account global trends (Keun-Wook, 2012; Henderson, 2015). Thus, for instance, in his work, J. Henderson studies the key factors defining the prospects in oil extraction and export by Russia, as well as analyzes the fundamentals of oil extraction in Russia taking into account the current low oil prices (Henderson, 2015).

Energy security issues are regarded in works by Buchan (2014), Buchan and Keay (2016).

3. MATERIALS AND METHODS

3.1. Forecasting the FEB based on the Systemic Approach

Taking into consideration the matter of the systemic approach and the increasing complexity of forecasting objects, including both FEC subsystems and various constituents of the energy balance, as well as factors influencing its dynamic characteristics and intensity of their change, mobility, the author considers it reasonable to be based on the existing general power industry forecasting scheme used in Russia when developing methodological aspects in FEB forecasting.

The retrospective analysis of the methodical base of FEB formation has shown that it was based on the results of works by A.A. Makarov and A.G. Vigdorchik and involved the "normative" energy consumption calculation method with subsequent energy balancing of particular kinds of fuel and uniting them into a summary balance (Makarov and Vigdorchik, 1979). Later, a method was developed to draw summary balance of primary energy resources and corresponding simulation models, which transferred report data in a unified FEB form developed in assistance with domestic scientists from the Energy Research Institute of the Russian Academy of Sciences and United Nations Economic Commission for Europe (official website of Energy Research Institute, 2017, https://www.eriras.ru/data/34).

Deploying systemic contours within FEB forecasting will facilitate prompt tracking of various changes taking place in the country's and regions' economy at all levels, as well as the stability of their energy security.

When fulfilling the objectives set by the analysis, forecasting, and planning, the author interprets a systemic contour as a multitude of subsystems and elements within the same contour interacting with each other and forming a particular unity.

Energy balance is a basic category in economic and energetic analysis which demonstrates a country's capabilities to provide for external and internal demand and facilitates outlining general development trends for particular kinds of fuel, types of power industries and user sectors. It is one of the main tools which allow carrying out general analysis of resourcing, production, consumption, and external trade of energy carriers. The structure of energy balances regarding both the resources and sources of use is rather inert (Markovich and Salikhov, 2007). In this regard, it is reasonable to use the systemic approach and the term "system" because the formation of FEB involves quite a great number of systems and subsystems of various levels which are interrelated and interinfluencing. The forecasting object is rather complex and not at all clear, but it definitely has all the attributes of integrity and unity.

Figure 2 presents an enlarged view of systemic contours forming during the achievement of various energy security management objectives based on the FEB.

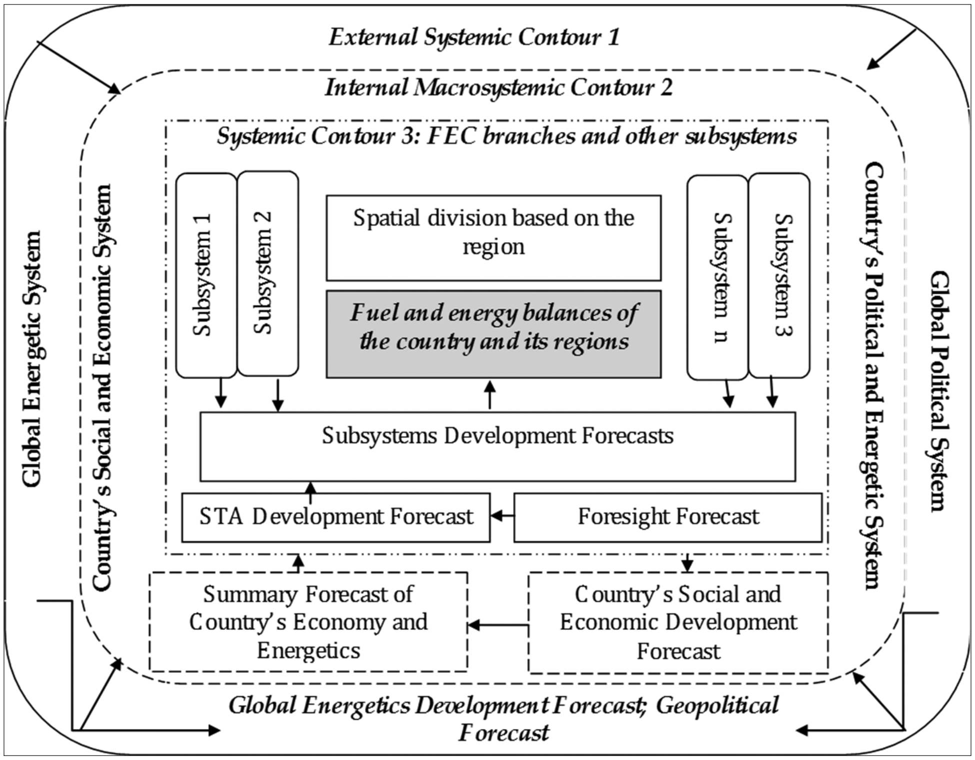
Practical use of the above mentioned approach based on the formation of systemic contours to achieve energy security management objectives through building energy balances both for the entire country and each region is not possible due to the absence of appropriate information assurance.

3.2. Information Assurance for Fulfillment of Methodological Principles of FEB Formation Based on Systemic Contours

Information assurance plays a key role in a country's systemic energy security management through formation of FEB. And it implies only not the formation of an information statistics field for each FEB section, but also the creation of a unified centralized database. Such an information system would allow accumulating all information necessary for the formation of FEB both at regional and federal level, including information assurance for forecasting at all levels of systemic contours.

Several research works focus on the formation of a unified information system which would accumulate and systematize data necessary for building FEB and monitoring it. In their works, S.D. Korovkin, I.D. Ratmanova, L.V. Schavelev, I.A. Levenets

Figure 2: Enlarged representation of systemic contours: subsystem. 1 – Fossil fuels; subsystem; 2 – Non-fossil fuels; subsystem 3 – Nuclear power industry; subsystem n – Other subsystems outlined within the FEB analysis, forecasting, and planning, e.g., based on FEC branches; STA – Science and technology advance



consider an opportunity to create a corporate information and analysis system for a region's FEB aiming at arrangement and integration of information based on its sources and consumers of fuel and energy resources in order to improve FEC management (Korovkin et al., 2005).

The author suggests forming an information and analysis system which would assure the formation, within each systemic contour, of an early warning system which allows responding to any changes promptly and thus ensure dynamic characteristics of FEB constituents.

Information must comply with the following key requirements: Reliability, topicality, sufficiency, and promptness. Such a system is to be based on hundreds of indicators, which would cover various FEB aspects and factors influencing it. Building such a system is quite a complicated process, and it is hardly possible without ideological and financial support from the government.

Moreover, it is necessary to note that part of forecasts regarding FEB formation are based on global trends in power industry, politics, development of global markets, etc. That is why the issue regarding the acquisition of authentic and reliable information obtained from global sources and necessary for such forecasts is rather topical at the moment. In his work, Al-Zayer A. Fuad noted the importance of international cooperation in the formation of an information field within global power industry. International cooperation in this aspect focuses on improving the quality of data about the power industry, as well as satisfying the increasing need in such detailed information (Al-Zayer, 2017).

4. RESULTS

During the research, the author attempted to emphasize the importance of using the FEB as an active tool in a country's energy security management and not as a tool to analyze the current situation. To make it happen, it is necessary to improve the quality aspect of FEB formation through building a methodological basis aiming at forming systemic contours which would facilitate structuring different subsystems influencing the FEB taking into account the spatial regional scope. According to experts, "the main issue in FEB development is incompleteness and low quality of statistical information. It is necessary to develop a method which could be widely used. Moreover, there is no coherent system for federal and territorial FEBs". To develop coherent forecasting of FEBs at country and regional level, a unified social and economic bases is needed, i.e. forecasts regarding the social and economic development of the country and regions (interview "Minenergo Sees No Need to Build FEB at Municipal Level", 2016). In this regard, it is suggested to form an information and analysis system which would provide FEB analysis, forecasting, and planning with necessary, topical, relevant, and authentic information. Another result of the research was detecting the need to form an early warning system to prevent any deviations from forecast and target FEB values in order to take prompt management actions to ensure stable energy security in the country. An early warning system implies analyzing the most current data about changes in global economy, global energetic system, industry and markets based on the main economic and industry indicators which allow forecasting crucial moments in the global energy market.

5. DISCUSSION

Issues regarding the formation of forecast FEBs have been discussed rather actively lately – in the scientific world, at federal level, by industry analysts and experts. Publications by I.A. Bashmakov, Executive Director at the Center for Energy Efficiency (CENEF) emphasizes the necessity and possibility to use a unified region's FEB being the main tool of development and monitoring of energy efficiency improvement programs (Bashmakov, 2012). Scientific and practical works related to the formation of forecast FEB, forecasting of energy consumption and research of a country's energy efficiency have been performed at the Energy Research Institute (ERI) since it was founded, and have always been among top priority objectives (official website of Energy Research Institute, 2017).

However, a number of publications note that insufficient attention is paid to the issues related to the formation of a unified forecast FEB by the state. It is not obligatory to build FEB at regional level, and it is to be used only as an information basis to assess the current situation in the retrospective period for groups of particular kinds of energy resources in order to form single-product balances.

Recently, this topic has been developed by the associate members of the Russian Academy of Sciences S.P. Filippov, A.N. Kurashev and E.V. Mokhina, and has been involved in the solution of various practical objectives. The most important among them were the preparation of supporting materials for the preparation of the Energy Strategy of Russia for the Period up to 2030, the formation of FEB of subjects of the Russian Federation complying with the country's FEB, and the analysis of the energy efficiency trends in the Russian economy and its particular sectors (Filippov, 2010). Here, one should mention that, in order to achieve the latter objective, it was necessary to build FEB at global level. But it is still an occasional need in FEB which is spatially limited (a certain number of regions taking part in the scientific project).

6. CONCLUSION

In conclusion, one should mention that the above mentioned suggestions on the development of methodological aspects of FEB formation are presented only briefly, without detailed explanation of aspects such as the systemic contours formation algorithm, which systems and subsystems will represent each contour, which set of indicators will characterize each system (subsystem), etc.

Although long-term forecasting issues are mentioned, the article hardly regards methodical issues concerning the formation of these forecasts. The formation of an early warning system for FEB monitoring has been mentioned just superficially. The author intends to discuss this and reveal it within subsequent research of the formation of high-quality FEBs with their corresponding characteristics.

At the same time, the goal of this article stated by the author, aiming at covering the trends in the development of methodological aspects of FEB formations has been achieved.

An integral system of formation of a unified FEB with high-quality information and analysis assurance will facilitate prompt development of FEC branches and, thus, ensure energy security in the country. And both scientific research and practical use of the obtained results must be supported both at regional and federal level through the creation of a corresponding updated normative base, as well as provision of grants for such research.

It is reasonable to agree with S.V. Alymov who notes that methodological principles of FEB formation, besides the general system requirements, must also ensure:

- Interaction of the FEB with investment programs;
- Possible diversification of fuel and energy within the balance structure;
- Harmonization of the rates at which conventional resources are replaced by alternative ones;
- Accounting of regional aspects of balance formation, accounting of technological capabilities and innovation constituent of the FEB, etc. (Alymov, 2012).

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