ISSN 1019-3316, Herald of the Russian Academy of Sciences, 2016, Vol. 86, No. 5, pp. 351–356. © Pleiades Publishing, Ltd., 2016.
Original Russian Text © O.N. Favorskii, V.M. Batenin, V.M. Maslennikov, V.V. Kudryavyi, S.P. Filippov, 2016, published in Vestnik Rossiiskoi Akademii Nauk, 2016, Vol. 86, No. 10, pp. 867–872.

Science and Society

What Is to Be Done to Implement Russia's Energy Strategy

O. N. Favorskii[a1], V. M. Batenin[b2], V. M. Maslennikov[b3], V. V. Kudryavyi[c4], and S. P. Filippov[d5, *]

[a] *Division of Energy, Machine Building, Mechanics, and Control Processes, Russian Academy of Sciences, Moscow, Russia*
[b] *Joint Institute for High Temperatures, Russian Academy of Sciences, Moscow, Russia*
[c] *MPEI National Research University, Moscow, Russia*
[d] *Energy Research Institute, Russian Academy of Sciences, Moscow, Russia*
e-mail: [1]ptped@oem.ras.ru; [2]vbat@oivtran.ru; [3]ivtmaslen@mail.ru; [4]nefedova@eurocem.ru; [5]fil@eriras.ru

Received April 22, 2016

Abstract—The elaboration of Russia's power development concepts that envisaged doubled and even tripled power production by 2030 in accordance with an order of the Russian Federation was already under way several years ago. Today these concepts are undergoing revision. In the context of the sharp decline in industrial production, the illusion has arisen that the situation with power supply is relatively satisfactory: production capacities exceed demand by more than 20%. However, this is achieved due to the exploitation of expired and outdated equipment. The wear and tear of fixed assets in power production exceeds the critical mark of 60%. The main negative trends in the development of the Russian energy industry are analyzed, and a number of measures to resolve the existing situation are proposed.

Keywords: energy strategy, innovations, investment fund, combined cycle gas turbines, energy technology.
DOI: 10.1134/S1019331616050038

The applicable document that prescribes the main vectors in the development of the country's power production is The Energy Strategy of Russia until 2030, which was approved by executive order of the Russian Government no. 1715-r on November 13, 2009. In addition, the scientific–technological development of the industries of the fuel and energy complex is defined by Russian Federation Presidential Decree no. 899 of July 7, 2011, Priority Trends in the Development of Science and Technology in the Russian Federation and a List of Critical Technologies of the Russian Federation; Forecast of the Scientific–Technological Development of the Russian Federation for the Period until 2030; Instruction of the Russian Government no. 1217-r of July 3, 2014, Approval of the Roadmap for the Introduction of Innovative Technologies and State-of-the-Art Materials in the Industries of the Fuel and Energy Complex; and the state programs Energy Efficiency and the Development of Power Production, The Development of Industry and Increasing Its Competitiveness, and The Development of Science and Technologies. A target vision of the strategy of the development of Russia's electrical power production up to 2030 and a description of major sections for forecasting scientific–technological development, such as energy efficiency and energy saving, are presented in the works [1, 2].

In accordance with Federal Law no. 172-FZ of June 28, 2014, On Strategic Planning in the Russian Federation, projects of energy strategy for the period until 2035, a forecast of the scientific–technological development of the fuel and energy complex industries, and an outlook for the development of power production until 2050 were worked out. None of these documents was either adopted or even discussed in a proper way. This shows that the traditional approach to the elaboration of such documents and the requirements on their implementation is a deadlock until certain fundamental issues are resolved.

Let us analyze the causes of the critical situation in the development of Russia's power production and try to substantiate the necessity of taking a number of measures to pull it out of this state. Let us see if we were right in proposing our point of view in the article "With what should we begin the implementation of the energy strategy of Russia?" [3].

First of all, note the necessity of correctly accounting for the unusually high uncertainty of many key

* RAS Academician Oleg Nikolaevich Favorskii is Deputy Academician-Secretary of the RAS Division of Energy, Machine Building, Mechanics, and Control Processes. RAS Corresponding Member Vyacheslav Mikhailovich Batenin is an RAS Advisor. Viktor Mikhailovich Maslennikov, Dr. Sci. (Eng.), is Chief Researcher of the RAS Joint Institute for High Temperatures (JIHT RAS). Viktor Vasil'evich Kudryavyi, Dr. Sci. (Eng.), is a Professor in the Department of Automated Control Systems of Thermal Processes at the Moscow Power Engineering Institute (National Research University) (MPEI). RAS Corresponding Member Sergei Petrovich Filippov is Director of the RAS Energy Research Institute (ERI RAS).

external factors, as well as new risks and challenges. Of importance is also the effect of geopolitical factors, primarily the negative response of leading foreign countries to the aspiration of Russia to regain the status of a superpower. It is largely geopolitical factors determined by the incipient transition to a multipolar world that cause the crisis phenomena in the global economy and the high turbulence of global raw materials markets, including the sharp decrease in the world oil prices, which are still one of the most important aspects of the formation of our country's GDP. There remains the risk that the restrictions for Russia and domestic companies on access to external financial resources and state-of-the-art technologies, materials, and equipment will persist for a long time. Threats to the transit of domestic energy carriers across the territory of a number of countries and just access to new and traditional energy markets are still clear and present.

In these conditions, developing an energy strategy with specified target performance indicators that would clearly be tied to definite time intervals becomes a difficult task. Nevertheless, the goal posed by the country's leadership—the creation of an economically developed and socially oriented sovereign state conducting an active foreign policy—requires defining the main principles and criteria of the activity of all industries of the economy, primarily power production. Deadlines for meeting various indicators can change depending on concrete internal and external conditions, while principles and quantitative criteria can change only under changes in the state's goals and objectives or in the technological mode.

In periods of economic decline and uncertainty in the functioning of external energy markets, the primary task should be to increase the efficiency of the energy sector inside the country. This primarily relates to electric power production, which is practically fully oriented today at meeting internal demand for electric and thermal energy. This is what the strategy of the development of electric power production within The Energy Strategy 2030, adopted in 2009, was targeted at. Its main drawback, however, was that it was not supported by any concrete implementation program and remained a mere scenario of possible development.

At first sight, the situation in Russian electric power production seems favorable. Ten years ago, its precrisis state was a great concern, while today, although no substantial changes have taken place, the acuteness of the problem has apparently disappeared; even excessive generation capacities have emerged. This is the result of the commissioning of new capacities according to the long-term capacity supply (LTCS) program, which is being implemented against the background of a sharp slowdown in demand for electric energy, which is too expensive for consumers. In reality, the situation in electric power production is not so rosy. The fixed assets are greatly worn out, the management system of the industry has been destroyed, capital construction uses cost-intensive mechanisms, etc.

An energy strategy should envisage an efficient program of its implementation, aimed at solving key problems of the industry. With respect to electric power production, it should at least include proposals on the improvement of the management system of development of the industry; the elaboration and assimilation of effective energy technologies; the development of relevant sectors of energy machine building, the electric power engineering industry, and the construction complex; and stable and cost-friendly financial support.

The experience of several years makes it possible to establish how the consequences of the disintegrative reforms in power production told on the execution of these major sections of the country's energy strategy.

The most important consequence of the reforms in electric power production was the practical liquidation of the industry's strategic agent, the function of which had previously been performed by RAO UES. At present, there is no agency that could have foreseen and solved the industry's problems on a timely and operative basis, and these problems are accumulating. The cost of fixed assets in generation was for many years up to 65% of the cost of fixed assets of electric power production. Today their wear exceeds 60%, and restoration by isolated wholesale generation companies (WGC) and territorial generation companies (TGC) is unrealistic in the near future.

Selling electric energy and heat in two uncoordinated markets (a wholesale competitive market sells electric energy, while heat energy is sold by a retail regulated market) and abandoning the priority of heat use efficiency in favor of price bids have led to unprofitability in energy sales of the largest and most socially significant urban central heat and power plants (with a total electric and heat capacity of about 300 GW). The violation of the principle of combined power supply priority provoked consumers to undertake large-scale construction of their own boilers.

The sector's problems boost the development of distributed generation in industry. In 2014, investments in it amounted to ₽40 bln, and the installed capacity was about 17 GW (7% of the total capacity). Despite the lobbying by "Big Energy," the law on the recognition of distributed power production as part of the energy industry has not been accepted thus far. Naturally, any coordination in choosing equipment and creating regional service centers, which substantially decrease operation costs, is out of the question.

In these conditions, the restoration of a full-fledged vertical integration in electric power production is difficult. A noticeable role is already played by private Russian companies, such as T Plus PJSC (formerly, KES Holding), the Siberian Generating Com-

pany LLC, and Quadra PJSC, and the foreign generating companies E.ON, ENEL, and Fortum. Corporate procedures on changes in the goals, objectives, structure, and managerial principles, which require changes in the legislation and consent of minority shareholders, are extremely involved, a buyback of the assets by the state being unreal and by state-owned companies (OOO Gazprom Holding, the Inter RAO PJSC), impossible. We should also bear in mind that all disorganizing and disintegrating measures, which were introduced in reforming electric power production, have powerful stakeholders. It is enough to mention Novosibirsk oblast in sales and local grid operators (LGO) in electric grids to understand that the recipients of hundreds of billions of rubles are greatly interested in this. The marketing of electric energy in the amount of ₽2.5 trillion was handed over to private companies. The recovery of decision-making centers in Russia's federal subjects will help restore controllability in electric power production by returning to the functional principle of separation of electric grid facilities. Even uniting the grid assets of the Federal Grid Company and interregional distribution grid companies on the territory of Russian federal subjects largely solves this problem: a real decision-making center would appear, and it could be turned into a single electric grid operator.

The ultimate goal, however, is recovery of the center of strategic control, an increase in energy security, and the formation of conditions to develop the country's economy and ensure the manageability of the electric power complex in the cardinally changed situation where Russia's UES and power complexes function.

At present, neither the Russian government nor the authorities in the Russian federal subjects have structures responsible for balancing the programs of the socioeconomic development of electric energy production and consumption by volumes and commissioning times of electric power and consumption facilities. It is a generating company that dictates the conditions proceeding from its possibilities to receive maximal profit. The financial consequences amount to a loss of hundreds of billions of rubles.

In developing the country's energy strategy, the results of the analysis of world tendencies in the development of electric power production were widely used. They include the creation of large gas-fired combined binary cycle turbines with an efficiency of up to 55–60% and up to 65% in the long term and coal-fired steam turbine plants with ultrasupercritical steam parameters, the use of renewable energy sources (RES), the development of distributed generation facilities, and so on. In the longer term, the large-scale use of ecologically friendly integrated coal gasification combined cycle turbines (a Joint Institute for High Temperatures (JIHT) patent of the 1960s) and natural gas and coal-derived gas fuel cells was considered.

It appears advisable to reflect more actively on domestic advanced developments in strategic documents. At present, the Russian Ministry of Industry and Trade jointly with the Ministry of Energy are forming a program to create domestic high-efficiency moderate-output and heavy-duty gas turbines. However, the creation of first-rate gas turbines will not solve the problem of the rational development of Russia's energy industry. They should be incorporated effectively into the respective electric power production technologies, primarily in combined cycle gas turbines (CCGT).

JIHT RAS has developed energy technologies the power production efficiency of which substantially surpasses the world level even when using current domestic gas turbines; these are plants superimposed on gas turbine units (GTU) of the existing RTS water-heating boilers; modernization of the existing boiler–turbine generators using GTUs with natural gas partial oxidation [4]; a combined cycle gas turbine with steam injection for the simultaneous production of electric energy, heat, and cooling [5]; and energy technology complexes with the production of electric energy, synthetic liquid fuel, and other valuable products [6, 7]. There are a number of interesting proposals from other domestic organizations.

In the next five to seven years, we should complete the creation of high-efficiency domestic combined cycle gas turbines for central heat power plants (CHPP) based on licensed and new domestic GTUs, including those developed by JIHT RAS for combined cooling, heat, and power generation (trigeneration) [5]. Practical implementation of such energy units will make it possible to replace old cogeneration plants of the T and PT types and to increase electric power production with a decrease in natural gas consumption and atmospheric carbon dioxide emissions.

The desirability of continuing developments in complex energotechnological use of fuel, primarily coal and natural gas, is explained by the potential demand for them when readily available and cheap hydrocarbon resources are exhausted.

Electric power production is by nature a monopoly industry and, from the point of view of controlling its development, cannot be allowed to float freely in the market. Energy production has very "long negative feedbacks"; the replacement of one technological mode by another requires a lot of time. For this reason, technologies created back in the 1930s and with inexcusably high specific fuel rates by today's standards are still in use.

With limited resources for innovative goals, it is necessary to choose technologies reasonably and to focus primarily on their development. The task is to compare on a correct basis the competing existing and proposed technologies under their increasingly complicated interaction with the electric energy system and the external (socioeconomic, natural, etc.) environment. To design a rational energy management

paradigm, it is necessary to have a system of ranking the existing advanced foreign and domestic energy technologies by economic efficiency, environmental safety, and readiness for practical application under varying external factors (fuel cost, location, financing terms, environmental restrictions, and so on). Such a system will make it possible to choose the most effective energy technologies to fulfill the strategy of developing the country's electric power production and, in addition, to control capital costs while building new energy facilities.

The Soviet Union used to make methodical efforts to standardize specific capital costs in all economic industries. The TEPLOENERGOPROEKT Institute developed standards of specific capital costs of thermal steam electric turbine plants. The lack of such standards today makes it impossible to answer the question why the specific investments in the construction of a CCGT unit of the same capacity and with the same plant mix is 1.5 times cheaper in the United States than in Russia. JIHT RAS used to apply successfully the methods of such simplified comparative techno-economic analysis in the 1980s in studies that were conducted within the mixed Soviet–American Commission on Environmental Cooperation [8]. JIHT RAS handed over its proposals to develop jointly with the ERI RAS and the Krzhizhanovskii Energy Institute a similar methodology with respect to the modern conditions to relevant government structures but has not received support thus far.

The creation of advanced energy technologies requires constant coordination in the activity of related economic sectors, the organization of interindustry R&D, the development of standard designs of energy facilities, the unification of the standard series of energy equipment, and the restoration of the production potential and staff composition in energy industries that would make it possible to conduct timely large-scale activities on the development and modernization of the industry and on recovery work after serious anthropogenic accidents. It is equally important to create economic and organizational prerequisites for a transition to the rhythmic feeding of domestic production, design, and construction–mounting complexes, which would ensure the replacement of outdated equipment and the construction of new generating capacities.

The methods existing in electric power production and schemes of managing its development, which are out of touch with correct forecasts of electric-power and heat consumption, have outlived their usefulness. At present, the load of more than 70% of new electric grid facilities is far from 100%. Note that outdated capacities have not been decommissioned for a long time due to weak system connections, the lack of heat supply sources for consumers, the antagonism of the system operator, and so on. Of no small role here is the desire of electric power business agents to secure their maximal profits, exploiting the facilities they purchased dirt cheat until their life is exhausted. The following internationally accepted funding models are not used for the same reasons:

• depreciation charges during the regular reduction of fixed asset renewal times in the electric energy industry until the lag in scientific and technological development is eliminated; this financing system has been basic in the US economy for more than 50 years, comprising up to 70% of investments in capital-intensive industries;

• project financing, under which the repayment of investor funds is secured not by the guarantees of energy companies but by the expertly confirmed efficiency of a new energy facility after putting it in operation; up to 10% of investments secure the financing of this mechanisms in various countries;

• the introduction of the IPP method (build, own, operate), which is based on the buyer's (a regional energy company, a consumer) guarantees by the volume and price of electric energy bought for the whole payback period; up to 100 GW of new investment projects have been implemented according to this method in the world;

• perennial preferential lending by governmental and transnational banks of development for a period of 25–30 years; from 10 to 20% of investment projects have been financed in various countries.

Certain investment activities were observed in the early 2000s due to additional stock issues, and they echo to this day. However, this was redistribution of proprietary rights and not standard investment. For example, after paying for an additional stock issue to create two 800-MW CCGTs, the new stockholder would acquire a controlling interest in an energy company with a capacity of 12 mln kW. Further modernization is of no interest for new and old WGC and TGC owners, who receive the maximal profits from operation.

Below are proposals to ensure the efficient implementation of the country's energy strategy.

• The formation of a *government institution* that organizes the development and introduction of innovative technologies and that has the necessary legal and financial capacities. This could be a specialized department of the Russian Ministry of Energy. Such a decision requires political will and financial investments.

In the current conditions, the management of the creation and implementation of innovations, to say nothing of import substitution, is possible only with the participation of government institutions. Note that the restructuring of OAO RAO UES Russia pursued the goal of government withdrawal from the sphere of energy production and its transfer to private hands. The State Planning Committee disappeared over the course of strategic transformation of the economy and

energy industry; the Russian Ministry of Energy has turned into an institution that has actually and legally lost the capacity to develop and implement innovations owing to the liquidation of its divisions, a sharp reduction in its financial opportunities, and its legal separation from the production sphere.

• The formation of a *centralized government investment fund* for financing innovative development of the Russian electric energy industry through an investment component of the electric energy tariff, i.e., investing into development at the cost of energy consumers [4]. The control of the fund's spending should rest on the consumers, which would make it most effective. The amount of the investment component in the tariff should be determined through the corresponding optimizing calculations (according to our estimates, it may be about \$0.005 per 1 kW h).

This funding of energy development is optimal. First, the consumer is interested in a low cost of electric energy and will justly track the rational spending of funds. Second, this is interest-free lending, the "financer"-consumer does not demand rapid return of the funds invested. Third, practically all energy producers have an investment component today. However, since it is insufficient for independent development of each independent producer, it is usually "guzzled," i.e., entered into profits or spent on "band-aiding" during the exploitation of worn-out equipment.

Since the government undertakes to invest in the development of the energy industry, the tariff's investment component can be legally and fairly withdrawn from the energy producer. As a result, the aggregate tariff for the consumer may remain at the same level or grow a little, especially since the consumer, having paid by the investment component for the capital costs, equivalent to the creation of his own energy source, should receive stocks and become a co-owner of the power plant.

The authors have brought forward the above proposal more than once [4, 9], and it was acknowledged as efficient, but concerns were expressed that the would-be fund would be pilfered. Meanwhile, to develop a transparent and efficient system of control over the fund's receipts and expenses is no big deal.

• The creation of a *system of transferring* innovative energy units made at the expense of the investment fund to the owners of power plants.

The practice of recent years shows that the implementation of innovations at operating power plants is extremely difficult. Investment at the expense of a centralized investment fund makes it possible to hand over a new advanced unit to an operating power plant with the right to receive a corresponding share of stock. This procedure (a public private partnership) is beneficial for the state as well as for the private owner of a power plant. The state receives dividends, returned to the investment fund, and the power plant's owner receives a new technology, which reduces operating costs and, consequently, increases the profitability of the existing stock. As a result, the state gradually, by replacing worn-out energy units, receives a controlling interest that makes it possible to implement the most efficient energy policy.

• The development of a *hierarchical system of efficiency, ecological safety, and a degree of readiness for the practical implementation* of alternative existing and proposed innovative energy technologies, taking into account the great uncertainty of external conditions and various high risks. The availability of such a system allows for the choice of optimal options of technological saturation at various stages of the implementation of the energy strategy and serves as a model for cost control for facilities under construction.

It is necessary to develop methods of predicting the technical-economic indicators of promising energy technologies, as well as the creation of a database of competing technologies (both current and new) with an adequate reflection of prognostic dynamics of their technical-economic and ecological indicators, among others.

• In order to ensure normal economic growth, *a law is necessary* that would oblige energy companies to provide electric energy for all consumers of the region under service without exception. The United States has such a law.

• The preparation of *proposals on mechanisms* that ensure the obligatory execution of the main provisions of the energy strategy by all agents of the energy industry.

REFERENCES

1. A. Yu. Grebenyuk, L. N. Proskuryakova, A. V. Sokolov, et al., *Russia's Scientific and Technological Development Forecast: 2030. Energy Efficiency and Energy Saving*, Ed. by L. M. Gokhberg and S. P. Filippov (NIU VShE, Moscow, 2014) [in Russian].
2. Yu. A. Zeigarnik, V. M. Maslennikov, V. I. Nechaev, and I. S. Shevchenko, *On Target Vision of Russia's Strategy of the Electrical Energy Industry Development until 2030*, Ed. by A. E. Sheindlin (OIVT RAN, Moscow, 2007) [in Russian].
3. O. N. Favorskii, V. M. Batenin, and V. M. Maslennikov, "With what should we start implementing Russia's energy strategy," Vestn. Ross. Akad. Nauk **85** (2), 99–106 (2015).
4. V. M. Maslennikov, V. M. Batenin, V. Ya. Shterenberg, et al., "Repowering existing steam-turbine units by topping gas-turbine units with partial oxidation of natural gas,"Therm. Eng. **47** (3), 228–238 (2000).
5. V. M. Batenin, V. M. Maslennikov, Yu. A. Vyskubenko, E. A. Tsalko, and V. Ya. Shterenberg, "A steam–gas power plant for combined generation of electricity,

heat, and cold (trigeneration)," High Temp. **52** (6), 913–919 (2014).

6. V. M. Batenin, V. M. Maslennikov, and L. S. Tolchinskii, "Energotechnological complexes as a promising way of developing fuel resources," Novosti Teplosnabzheniya, No. 4, 26–31 (2014).
7. V. M. Batenin, V. M. Maslennikov, and Yu. A. Vyskubenko, "Complex emergotechnological use of coal," Izv. Akad. Nauk. Energetika, No. 5, 15–21 (2011).
8. V. M. Maslennikov, Yu. A. Vyskubenko, V. Ya. Shterenberg, G. R. Smitson, F. L. Robson, and V. T. Lokhon, *Combined-Cycle Plants with Intracyclic Gasificatiom of Fuel and Environmental problems of Power Engineering* (Nauka, Moscow, 1983) [in Russian].
9. *Russia's Power Engineering: A Look into the Future (Substantiating Materials for Russia's Energy Strategy for the Period until 2030)* (Energiya, Moscow, 2010) [in Russian].

Translated by B. Alekseev