

The influence of the market type in the electric power industry on its reliability on the example EPS of Russia

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Abstract. In modern conditions of competition in international markets, the cost of electricity has a huge impact on the ability of state to produce a competitive product. The percentage of electricity costs to goods manufactured in Russia is 2-2.5 higher than European countries, which undoubtedly affects competitiveness, and therefore leads to a decrease in Russia's growth rate. Therefore, work on the effectiveness of the energy industry is very important. The article discusses the mechanisms of energy markets, their features are given. The influence of selected mechanism on necessary full reserve of power is shown, the author's vision on further actions in these matters is given.

1 Introduction

In December 2000, RAO UES of Russia submitted for approval by the Russian Federation Government concept of restructuring the industry. The transition to market relations was supposed, but their form was subjected to serious discussion and criticism from scientific and production organizations. Despite this, with minimal changes, the concept was adopted and in February 2003 the State Duma of the Russian Federation adopted the Law "On Electricity".

If you see the adopted law shows that not one of the goals set in it is aimed at reducing electricity prices, ensuring energy security, sustainable functioning, and attracting investments. As a result of the electric power industry reform a Russian power market was created. Wholesale trade in electric energy in the federal wholesale electricity and power market (FWPEM) was organized. FWPEM was a system of contractual relations of many participants.

In the desire of mankind for competition, the development of markets in the electric power industry is inevitable, but it in view of its special nature and significance for the state cannot be uncontrolled. Over the years of the development of market relations, it is customary to distinguish between four types of markets [1,2,3 and so on]: an adjustable natural monopoly, the only buyer, competition in the wholesale market and retail markets.

The article [4] considers the influence of these market models on the final price. In this, we consider the effect of the influence of various market models on the level of reliability, all other things being equal.

2 Market models

Consider each of the models from the position of ensuring their reliability and predictability the energy system.

Adjustable natural monopoly. This type of vertically integrated companies usually subject to state regulation. In its absence, rising prices would occur. This type of markets is very natural for electric power, due to the characteristics of the manufactured products and the need to maintain proper reliability. This option increases its positive qualities as the system enlarges.

Monopoly companies plan the development of the EPS (both power plants and electric networks) on its territory, based on ensuring the reliability and efficiency of power supply to consumers, environmental requirements, etc. Plans for the construction of new power plants and power lines are subject to coordination with the regulatory authority, after which Construction costs are included in the form of an investment component in electricity tariffs. Thus, the costs of the EPS development is guaranteed to be paid by consumers.

The only buyer. This market model differs from the previous separation of the generation sphere into several economic independent electrogenerating companies (EGCs), which compete with each other for the supply of electricity to a single procurement agency. New electricity manufacturers (NEM) may also appear. The remaining areas remain integrated within the framework of one company, which is still a monopolist in relation to consumers. Naturally, this company (Purchase agency) should, as before, be regulated by the state.

The company "Purchase Agency" retains the obligation to ensure uninterrupted supply of consumers. What implies early planning and implementation the development of EPS on its territory in order to avoid

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electricity deficiency. Power supply contracts are individual in nature aimed at creating conditions for the development of uninterrupted deliveries. The procurement agency, in advance plans the development of EPS, predicts the power consumption, makes up promising balance and energy balance sheets, etc.

Competition in the wholesale market. This model is significantly different from the previous ones. Instead of one Purchase agency, several distribution and sales companies (DSC) appear. These companies, as a rule, do not have their own generating capacities and monopoly supply consumers with electricity on their territory. They are responsible for reliable power supply and remain subject to regulation by regional or municipal authorities. They own the distribution networks of low voltage, which they must develop if necessary.

In this market model, control over the development of energy system and maintaining the proper level of balance reliability are entrusted to an independent system operator (SO). At the same time, the presence of a wholesale market deprives consumers of a privileged position, which gives market power to suppliers and negatively affects the capabilities of the system to predictably develop and maintain a proper level of reliability. Now for this it is necessary to create economic capabilities, which significantly affects the increase in the tariff for power.

Competition in wholesale and retail markets. In addition to Model 3, the possibility of competition in retail markets is created here. Electricity consumers can now be supplied from different DSCs or sales companies (SC). Since the distribution of electricity remains a monopoly sphere, the state regulation of DSC is preserved.

The model provides for direct supply of electricity from manufacturers to consumers, bypassing DSC or SC. This means either the direct access of consumers to the wholesale market, or some combination of wholesale and retail markets. At the same time, of course, the procedures for accounting, mutual settlements, etc. are complicated.

At the same time, the market is preserved and even aggravated by problems with the construction of new power plants. There is still no body responsible for the development of generating capacities and the prevention of deficiency in the wholesale electricity market.

3 The influence of the market model on the formed reserve value

Consider the influence of the presented market models on formed full reserve value. In a few words about the task of substantiating a power reserve. The full reserve consists of three components, the most difficult to determine is an operational power reserve. The other two components are repair and strategic reserves, which, in conditions of redundancy the energy system, loses its significance. The repair reserve has a minimal impact on the indicators of balance reliability.

The determination of the value of the operational reserve of power is two-stage. At the first, for a given

composition of generating sources, and, consequently, the values of the operational power reserve, the task of assessing the indicators of balance reliability (IBR) for all territorial EPS zones is solved. On the second, depending on the results of the IBR and the accepted regulatory values, the specified initial parameters the operational reserve of power are corrected.

In relation to our country, the most acceptable in the practice of planning the development of the EPS remains IBR in the form of the integral probability of the appearance (J_n) or the absence ($p = 1 - J_n$) of the power deficiency in the territorial zones of the EPS design scheme. As normative parameters of this indicator in the methodological recommendations [5], the values of 0.004 and 0.996 are used, respectively. In the countries of Western Europe and the United States, several different, but also probabilistic IBR and normative values for them. In our country, many works are devoted to the development of IBR assessment models, for example [5-8].

The value of the power reserve is primarily affected by the predicted demand and the accepted indicators of balance reliability. The second for one country is constantly, and the first parameter changes depending on the selected market model in the energy system. Consider in order each of the models from this position.

With an adjustable natural monopoly as with the "only buyer" model, the only managing body is responsible for the development and safety of the energy system. He plans to input power on its territory based on the actual necessity and economic feasibility. Since the cost of input power is included in the form of an investment component in tariffs for electricity, the work on introducing capacities will always be paid, and therefore there are a lot of people who want to invest in new generating objects, which removes a number of uncertainties, primarily the need to interest a potential investor. The possibility of point input of capacities also contributes to a smaller volume of their input, which in the market will significantly affect the tariff.

The model based on competition in the wholesale market implies control over the development of the energy system through an independent system operator. His power includes decision making in the volume of the necessary input of capacities for uninterrupted operation of the energy system. At the same time, these solutions are often dictated by the need to create an economically reasonable investment base. This is a very important point, since it must be understood that in this market model market power on the side of suppliers, which means they dictate the conditions under which investments are interesting to them. Initially, in order to remove part of such risks and attracting those who wish to build a new generation, a program of contracts for providing power (CPP) was created, which guaranteed the refund of invested funds, since without it the existing tariff for electricity and strange risks did not attract those who wanted to participate in the investment program.

In the model based on competition inside the wholesale and retail markets, there are the same problems as in the previous one, only the scale of the problems is even more. There are still no control of the

unified managing body on the issues of promising development and compliance with the proper level of reliability.

4 The tariff effect on the formed volume of installed power for different market models in the electric power industry

Consider the influence of the presented market models on the required volume of installed capacity. Suppose that for all market models, in the formation of a model of promising development, criteria were used to maintain the reliability of the energy system according to the STD. Suppose (from [4]) that in the EPS there are sixteen power plants of power suppliers (table 1). Conditional costs of suppliers are random numbers in monetary units (units).

Table 1. Characteristics of power plants

№	Passed power, MW	Conditional constant costs, units.	Specific conditional constant costs, units/MW
1	1100	11000	10
2	1400	42000	30
3	500	19000	38
4	1700	68000	40
5	465	19065	41
6	550	24750	45
7	1200	55200	46
8	300	16500	55
9	405	23490	58
10	500	30000	60
11	160	9760	61
12	1200	73200	61
13	240	15600	65
14	35	2345	67
15	750	56250	75
16	500	45500	91
Sum	10725	1136120	

The results of solving the problem of determining value for power suppliers the considered models are shown in Fig. 1.

According to [4], the first two models will be workers at a tariff value lower than for model 3 and 4. So for 1 and 2 models, the level of installed power is 8280 MW, while for two other models 9755 MW. This is primarily due to the departure from the programs for creating CPP's in favor of the prices obtained through a competitive power selection (CPS), which should have the necessary investment attractiveness for options with a purely market mechanism of relations between subjects in the electric power industry. All this, coupled with an increased duration the CPS, and therefore the increase in

the error of planning the maximum load when forecasting demand leads to an increase in the predicted demand.

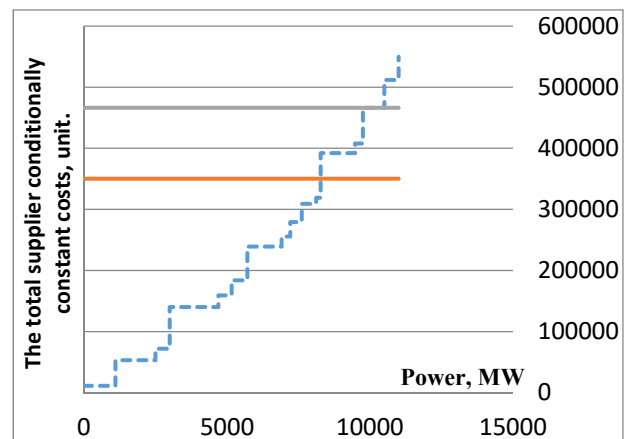


Fig. 1. Total conditionally constant costs of electric power suppliers and recommendations received according to the level of power value. 1 and 2 market type (red line), 4th market type (gray line).

The procedure for determining demand is carried out in accordance with Order No. 431 according to which it is formed from the value of the combined maximum load and the planned reservation coefficient. The analysis given in [9] shows that the value of the combined maximum load grows with an increase in the advance period. Moreover, this growth is in no way associated with the analysis of retrospective information about a change in the actual parameters [6]. Given the data of Scheme and development program EPS on 2021-2027, it can be seen that an increase in the forecasting period of up to six to seven years will lead to at least a 4 percent increase in the maximum load in both price zones of the EPS of Russia. All this directly affects both the high demand and the determined power reserve, and therefore the necessary volume of installed power.

5 The influence investment component on the level required power reserve

In [1], the process of obtaining all the necessary indicators is presented in detail, here we will present the influence of these indicators on the reserve size.

In Russia, countries of Western Europe, the United States and a number of other countries, the co-renewal of the investment component of tariffs and prices for the competitive market is 0.171, while the “only buyer” for markets is 0.0625, and for the regulated monopoly-0.052. Which by 2.7-3.3 times increases the influence of the investment component on the price of electricity. And the higher the country's industrial development, the greater the effect has it. In fact, this value indicates the necessary for new power plants excess of wholesale prices over the costs of similar existing power plants. This excess creates a price barrier to enter the competitive electricity market for new manufacturers.

In regulated monopolies and in the “only purchase” market, the investment component of the tariff will

depend on the composition and proportions of new (under construction) power plants. The final investment component will depend on the optimal composition (and capacities) of new power plants.

Since the investment attractiveness is primarily economic, the guaranteed value for electricity most strongly affects it. And it also depends on production costs that are different in different types of power plants. With adjustable markets (mechanisms 1 and 2), the weighted average generation costs will be determined by the structure of existing power plants. If you use the data presented and transfer it to the structure of the introduced generating capacities, then with the same payback periods, regulated markets will reduce capital costs 2.8 times. Which for our example corresponds to a decrease in the required installed capacity by 3-5%.

6 Full power reserve for different market models

We analyze the information about the predicted and actual demand and the necessary coating. To do this, we turn to Scheme and development program EPS of Russia [10]. Table 2 shows excerpts from Scheme and development program 2011 to 2022.

Table 2. Power Balance EPS of Russia

Year	Maximum consumption, GW	Change the year by the year, %	Coating, GW	Change the year by the year, %
Predictable values				
2014	168809		236850,4	
2015	173096	2,54	240725,2	1,64
2016	177475	2,53	244637	1,62
2017	181478	2,56	242291,3	-0,96
2018	165151	-9	232516,4	-4,03
2019	166262	0,67	232335,4	-0,08
2020	160484	-3,47	232620,4	0,12
2021	161311	0,51	225686,2	-2,98
2022	162011	0,43	228545	1,27
Actual values				
2011	153973	1,61	200346,6	-0,6,4
2012	158988	3,25	207362	3,5
2013	158659	-0,21	207700,5	0,16
2014	157219	-0,91	213875,1	2,97
2015	158871	1,05	223733	4,61
2016	154116	-2,99	215379,9	-3,73
2017	157355	2,1	221166,2	2,69
2018	156570	-0,5	215904,4	-2,38
2019	159360	1,78	218713,4	1,3
2020	155003	-2,73	217433,8	-0,58
2021	157543	1,64	217082,6	-0,16
2022	156946	-0,38	221925,1	2,23

Table 3. Full reserve for various market models

Year	Full reserve predicted (model 4), %	Full reserve actual (model 4), %	Full reserve predicted (model 2), %
2011	-	30,12	16,4
2012	-	30,43	16,23
2013	-	30,91	16,07
2014	40,31	36,03	14,9
2015	39,07	40,83	15,82
2016	37,84	39,75	15,04
2017	33,51	40,55	15,55
2018	40,79	37,9	14,69
2019	39,74	37,24	14,42
2020	44,95	40,28	15,07
2021	39,91	37,79	14,83
2022	41,07	41,4	15,33

Table 2 shows that the forecast is always highly overstated, despite the presence of huge excess power (table 3). This is primarily due to the need to ensure attractiveness for potential investors, which requires a comfortable tariff level for them, i.e. At the forefront, it is not the optimization of the system and a decrease in the tariff in favor of the consumer, but the work on the supplier. This is the main difference between models based on competition without direct control of the state and models that implies this control. For comparison, the use of models 1 and 2 allows you to focus on forecast demand, taking into account 2-3 years in the future, which reduces the impact of the forecast error and does not depend on economic attractiveness, which is achieved by direct control over the introduced capacity and guaranteed payment for its construction. With this in mind, the "Orion-M" program was simulated necessary the level of a full reserve taking into account the same level of normative reliability as in other market models. The results are presented in table 3. It is clearly visible more than two multiple advantage of models with state control over purely market mechanisms.

7 Conclusions

Electric energy is a resource that does not have an alternative, so the creation of any kind of markets raises questions. The idea of market works when there are various alternatives to the same product, in the case of electricity, this is not so. Therefore, the adopted model of the energy market directly affects the method of monitoring the reliability of the energy system its ability to predictably develop.

The studies show that models 1 and 2 make it possible to achieve predictions of the energy system, to simplify the task of maintaining due reliability. In addition, the adjustable market will reduce the problem of the price barrier for new generating capacities. With the current structure of the energy industry, the construction of a new generation requires a significant increase in price. Partly because of this, the price of selected capacities as a result of a CPS to strive for the value that allows to finance new objects without using the CPP mechanism. This drawback of the electric

power market in the long term can be overcome only through state regulation.

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