Power price in the conditions of market relations UES of Russia

Mikhail Chukreyev[1,*]

[1] Institute for Socio-Economic & Energy Problems of the North Federal Research Center of the Komi Science Centre of the Ural Branch of the Russian Academy of Sciences, Syktyvkar, Russia

Abstract. In modern conditions of market relations in the electric power industry, a mechanism is needed to regulate the purchase and sale of power, which should not lead to a deterioration in the EPS reliability. Competitive power take-off became the main component of this mechanism. Within its framework, nuclear power plants, hydroelectric power plants, new power units, as well as thermal power plants, which are necessary for heat supply to consumers, are mandatory selected. The article examines the process of price formation for capacity, its relationship with demand, shows the main features that affect its final indicators.

1 Introduction

In the early 2000s, as a result of the reform in electric power industry, the Russian market for capacity electricity was created. To date, the model has undergone a number of changes, but the basic principles laid down then work and now. However, there will always be controversial issues in the operation of any complex system, and the capacity pricing model is no exception.

At the time the market was created, the main problem was to provide high-quality generating capacity to rapidly growing consumption. This must be done in advance, because commissioning of generating facilities takes time, during which the existing fund inevitably grows old. To solve this problem, it was necessary to create a competitive environment in the energy sector, to separate Russian joint stock company "UES of Russia" by type of activity, to attract investments and to privatize assets in potentially competitive types of activity [1, 2].

Simultaneously with the division of Russian joint stock company "UES of Russia", wholesale trade in electrical energy was organized on the Federal (All-Russian) Wholesale Market for Electricity and Power (FWMEP). FWMEP was a system of contractual relations of many of its participants (subjects). For the final consumer of the retail market, if he is not a population or an equivalent category of consumers, the cost consumed electricity consists of several components:

- the cost of electricity directly purchased by a sales company on the wholesale market;
- the cost of capacity, which is formed from the capacity selection procedure (CSP), the capacity of the competitive selection procedure of modernized capacities facilities (CSPMod), Long-term power contracts (LTC), renewable energy sources (RES), hydroelectric power plants and nuclear power plants, the cost of new generation capacity in Crimea and Far East;
- cost of electricity transmission services and electricity losses in networks;
- sales markups.

The first 3 indicators form the price by 95-98% and the last by 2-5%. Let's consider the first three components in turn.

2 Electricity price

The price of electricity is most influenced by the cost of energy resources. Therefore, the final price directly depends on the cost of electricity production at the most inefficient plant in the price zone. In the European part of Russia, CHP plants run 80% on gas and about 20% on coal (other types of fuel are not of high importance, therefore, they can be excluded from the analysis), in Siberia and Far East the situation is the opposite, where 80% of CHP plants run on coal and only about 20% on gas. Based on this, the main effect on pricing is the cost of energy resources. Its rise or fall, one way or another, will directly affect the final price of electricity. In addition, the final price is influenced by the perfection of the equipment, and therefore the introduction of new generation limits the growth of the price of electricity. Thus, while gas prices have increased by 43% over the past five years, electricity prices have increased by 19%. Another important factor affecting the price of electricity is the balance of supply and demand. Since pricing takes place at the most expensive price, the higher the demand, the more expensive the supply will be.

3 Power price

From the point of view of pricing, the price of power purchased on the market consists of 3 components [3, 4]:

- Power taken at capacity selection procedure
- Power supplied as forced generation (FG)
- Capacity supplied to the market under Long-term power contracts

* Corresponding author: mchukreyev@gmail.com

Capacity tariffs are set for generators which are deemed necessary to operate on the market (backbone generators whose decommissioning is impossible for technological reasons). This tariff is always higher than the CSP price. At the same time, not all generation can receive a tariff, but only one that will be approved by the Ministry of Energy and the System Operator (SO). The more generation will be introduced, the more CSP will not pass it.

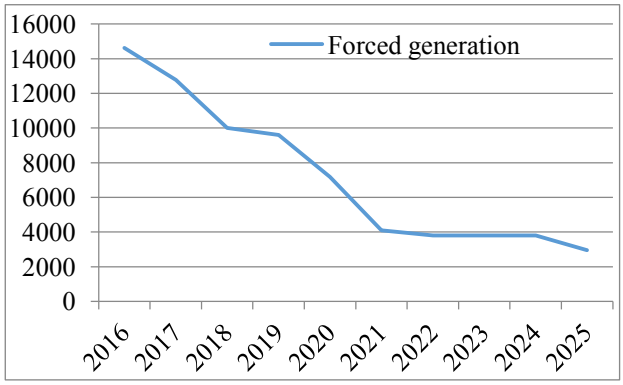

Fig. 1. Power selected as forced.

Figure 1 shows a picture of the change in forced generation over 10 years. The general tendency is to reduce the volume of capacity selected according to tariffs for generators operating in a forced mode. This is due to the often multiple excess of this tariff over the CSP price. The influence of this component on the resulting price CSP is gradually decreasing (Figure 2).

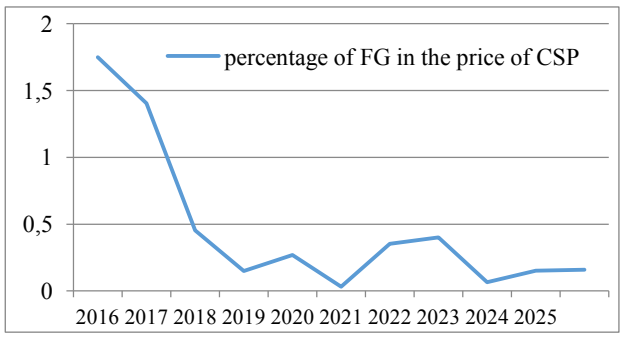

Figure 2 – Price component of CSP from FG.

During the reform Russian joint stock company "UES of Russia", a model was formed according to which all generation was sold with obligations to commission new stations or units, these agreements were called the "Long-term power contracts". The essence of the LTC is that the state guarantees payment and profitability for these projects at a certain level, which was recorded in the documents that were signed between buyers and sellers in the market. As with forced generation, the price of LTC is significantly higher than the price of CSP and the payment for this category is borne by the consumers of the price zone in which the LTC capacity has been taken. Below is a graph of the selected capacity under LTC from 2016 to 2025 (Figure 3).

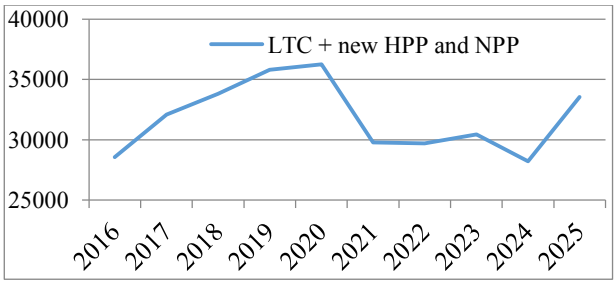

Fig. 3. Capacity selected under CSP from 2016 to 2025.

Capacity selection procedure is essentially the most market-based procedure out of 3. In 2015, a new CSP model was presented, which implies long-term selection by price zones using an "elastic demand curve". The plans to launch a long-term CSP have been discussed since the establishment of the capacity market in 2010. The three-year capacity payment guarantees, according to the original plan, were to increase the attractiveness of this market segment as a mechanism for attracting investments. Theoretically, the CSP should be used in the future instead of the LTC, which is unreasonably expensive for consumers. An elastic demand curve should create effective price signals for generating companies to decommission equipment - this tool should solve the problem of excess capacity in the UES of Russia. The elastic demand curve assumes that if the supply of capacity exceeds a predetermined limit, then the total price of the CSP is below the price ceiling (Article 32, paragraph 1 [5]). This CSP model assumes power take-off in two price zones, and not in 21 "free flow zones".

Let's consider how the CSP model works and evaluate what changes were made in 2015. To understand the CSP model, we will use a single-node isolated electric power system (EPS), in which there are no losses and restrictions on the volumes of transmitted power. EPS has many power suppliers (power plants). Power suppliers are characterized by the following indicators:

P_i - is the available capacity of power plant i;

C_i - conditionally fixed costs of power plant i (or conditionally fixed costs minus the profit expected in the electricity market).

For the demand for power P_c, varying from 0 to the total installed capacity of all power plants in the EPS, consider the total conditionally constant costs of suppliers selected in the power market in a certain system. Suppose the EPS contains 15 power plants with installed capacities and conditionally fixed costs, given in a random way.

CSP model until 2015. The predicted demand for capacity P_c is specified, which does not depend on the price of capacity. Capacity suppliers form applications for CSP. The bid consists of the supplier's capacity P_i and the price of this capacity c_i. Suppose that the price is related to the supplier's cost of maintaining capacity by the expression:

$$c_i = C_i / P_i . \quad (1)$$

During the CSP, the submitted bids are sorted in ascending order of price c_i and power plants are determined by sequentially selecting them in ascending order of price c_i. The selection is carried out until the total available capacity of the selected power plants equals or exceeds demand:

$$max(c_i) \text{ -> } min \quad (2)$$

with restriction

$$\sum P_i \geq P_c \quad (3)$$

The price of the most expensive selected unit of capacity becomes the price of capacity in the price zone:

$$c = \max(c_i) \quad (4)$$

This option was used for capacity selection procedure in the Russian Federation until 2015 and was carried out in free-flow zones annually for a period of 1 year.

CSP model after 2015. The current CSP model differs from the previous one in that demand depends on the price P_c *(c)*. In this case, the "demand curve" is set as a straight line starting at point 1 and passing through point 2. Points 1 and 2 are set as follows: the volume of demand for capacity at point 1 corresponds to the projected volume of demand, the volume at point 2 corresponds to the projected volume, increased by 12 %:

$$P_1 = P_c \, , P_2 = 1{,}12 * P_c \quad (5)$$

The price at both points c_0, c_2 is set by the Government of the Russian Federation.

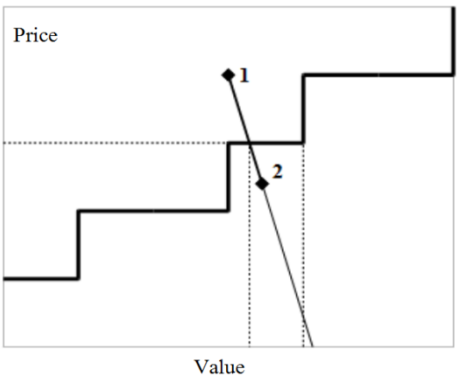

Fig. 4. Graphical representation of CSP with price-dependent demand.

The volume of the selected capacity and its price are determined by the intersection of the supply function obtained by ordering bids in ascending order of price, with the “demand curve” (Fig. 4). This option applies to price zones for a period of six years in advance with annual price indexation for suppliers selected based on the results of the CSP.

Let's try to see these changes with an example. Suppose that the EPS has fifteen power plants that supply power (Table 1). Conditionally fixed costs of suppliers random numbers in monetary units (units).

The results of solving the problem of capacity selection procedure according to the considered models are shown in Figure 5.

It can be seen that the use of the model with elastic demand slightly changes the selection of suppliers, but it does so in a rather narrow range of capacity (in fact, a price corridor was organized). That is, the change in the CSP model does not save the cost of maintaining capacity, but is primarily aimed at greater variability in the provision of capacity (to sell more capacity, but at a lower price, or a smaller volume of capacity at a higher price). For example, for a projected demand of 5200 MW, both models select all suppliers up to the 10th, providing a total cost of maintaining capacity of 285,805 units. For the projected demand value of 5500 MW, the results differ. Option 1 gives a cost of 285,805 units. (first 10 suppliers selected). Option 2 gives a cost of 305325 units. (selected all suppliers except 12-15). The numbers of the suppliers selected in these two cases and their total costs are shown in Table 2.

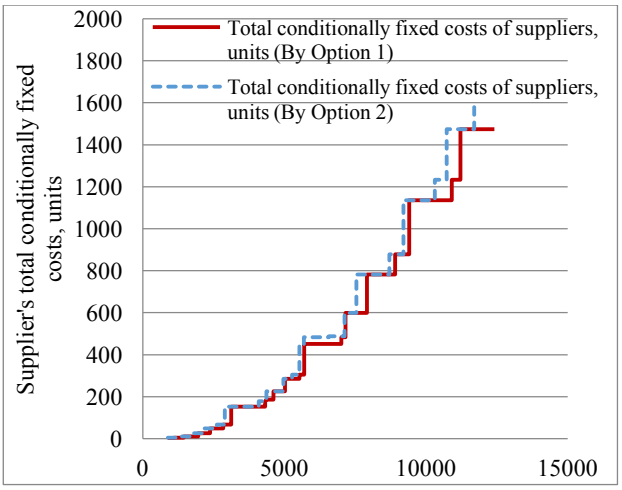

Fig. 5. Total conditionally fixed costs of suppliers of electric power selected as a result of CSP for a) a linear model with demand that does not depend on price (CSP until 2015); b) a linear model with price-dependent demand (CSP since 2015).

Table 1. Characteristics of power plants.

№	Available capacity, MW	Conditional post costs, units	Unit conditional post costs, units / MW
1	1100	3300	3
2	350	1400	4
3	500	5500	11
4	425	15725	37
5	465	22320	48
6	275	18975	69
7	1200	85200	71
8	300	25500	85
9	405	47385	117
10	500	60500	121
11	160	19520	122
12	1200	146400	122
13	240	31200	130
14	35	4725	135
15	750	111750	149
SUM	7905	599400	

Table 2. Selected suppliers and total capacity costs for different variants of the capacity market model.

Projected demand, MW	CSP model until 2015		CSP model after 2015	
	Suppliers	Costs, units	Suppliers	Costs, units
5200	1-10	285805	1-10	285805
5500	1-10	285805	1-11	305325

It should be understood that the changes were primarily aimed at increasing interest in investments in the construction of new generation by moving away from LTC in favor of prices obtained through CSP. Conducting a CSP for a six-year perspective imposes the need to forecast demand for the same period. Consider the impact of changes in demand on the price selected as a result of the CSP.

Table 3. Components of the CSP.

Component,% \ Year	21	22	23	24	25
LTC	13,1	12,63	0,771	2,667	3,19
FG	0,524	0,421	0,043	0,16	0,152
Demand	3,844	8	0,614	2,507	4,254
Rate	117,5	121,1	101,4	105,3	107,6
The influence imperfection of order No. 431 in terms of taking into account the temperature factor	0,307	0,64	0,049	0,201	0,341
The influence lead time of the load forecast	0,039	0,083	0,007	0,027	0,047
Influence of both factors	0,347	0,723	0,056	0,228	0,388
Reduced to 1% rate increase	0,02	0,034	0,039	0,043	0,051

It is clearly seen that the demand for a direct line affects the generated price, and an increase in the forecasting period leads to an increase in the planning error for the maximum load. The procedure for determining the 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 reserve ratio. The analysis given in (Chukreev Yu., Chukreev M. Components of the power balance consumption and their influence on the procedure of competitive power selection of the UES of Russia // current collection) that the value of the combined maximum load grows with an increase in the lead period. Moreover, this growth is in no way associated with the analysis of retrospective information on changes in actual parameters [6]. Taking into account the data provided in the work SPD for 2019-2025 it can be seen that an increase in the forecasting period to six to seven years will lead to at least a 4% increase in the maximum load in both price zones of the UES of Russia. To this should be added the inconsistency of the NTD in the form of Order No. 431 and MR 2003 in terms of taking into account the temperature factor of the cold season. This factor is taken into account in the Russian Ministry of Energy approved by the MR 2003. Thus, an increase in the lead-in period during the CSP and the inconsistency of different NTDs lead to at least a decrease in demand for capacity by 8%.

Table 4. Contribution to the unit price of energy costs.

	Energy efficiency costs per unit of production,%
Metallurgists	18.5
Coal miners	13.9
Agrocomplex	4.5
Refining	51.8
Pulp and paper	21.2

Table 5. Contribution to the cost of expenses year-on-year.

	Contribution to the cost of expenses year-on-year (19/20),%			
Company	Rate	Finished product price	Margin	% of margin
Metallurgists	1,1	-19,6	12,1	9,091
Coal miners	0,9	-13,7	18,3	4,918
Refining	3,7	-33,3	10,2	36,274

All these actions lead to an increase in the price of CSP, which would seem to improve the investment attractiveness, but this also leads to a further increase in the reserve, an increase in its share in the total tariff and an increase in the cost of all manufactured products.

At the same time, such activities are pushing more and more large industries to move away from centralized power supply in favor of their own power supplies with lower prices and maintenance costs. And this, in turn, leads to an even greater burden on other consumers.

4 Transfer rates

The first component is an investment program, according to which grid companies should build lines, substations, and update current equipment. During the reform of the energy sector, plans were laid for the grid companies to significantly increase demand and, accordingly, generating capacities. This was based on the available statistics for the last 10 years by that time. But at the same time, they did not take into account that these indicators were largely achieved due to the "low base". In fact, in the period from 2010 to December 2019 by 7%. And in the first half of 2020, this figure dropped to 3.2%. Of course, in addition to the two economic crises (which always exist and will repeat), the desire of consumers to optimize their consumption, including through new technologies, also played a role. All this has imposed an additional burden on consumers who are forced to pay for these unnecessary opportunities of the "transport" system. Many of them preferred to develop their own generation, which further increases the load on the rest. On this basis, recently, many investment programs of grid companies have been revised and adjusted. This problem is typical for countries all over

the world, since technical re-equipment is an expensive process, but it must be carried out in the energy sector every few decades.

Another important aspect is the large number of network companies. At the time of the start of the reform, there were more than a hundred of them, now this figure is much lower and the impact on the tariff is insignificant.

Last but not least, the so-called cross-subsidization is when the costs of transporting electricity for the population are partially transferred to the bills issued to industrial enterprises. The crossroads problem is quite significant for many regions of the Russian Federation, but at the moment no decision has been made on this problem. There was an attempt to partially start reducing this component, but at the moment everything remains as it is.

5 Conclusions

Having considered the main components of the tariff, two main areas can be distinguished, where, in our opinion, changes should be made to the existing model. The first is the change in the form of price formation based on the results of the CSP. In our opinion, it would be more correct to conduct a CSP for 3 years with price fixing, and for the next 3 years to indicate approximate prices with their further refinement in each subsequent year. This will reduce the error in load prediction. The second thing is that it is necessary to change this discrepancy between the NTD in the form of Order No. 431 and MR 2003 in terms of taking into account the temperature factor of the cold season. This factor is taken into account in the MR 2003 approved by the Russian Ministry of Energy. In its current form, together with an increase in demand forecasting, this leads to a 3-5% increase in the tariff, and if we take into account that the excess demand is also included when taking into account transmission tariffs, the figure rises to 6-9 %. One cannot ignore the problem of growth in payments under LTC, which, according to the current plan, will begin to decline only by 2027. It should be understood that the modernization or construction of modern generation will not lead to a decrease in the tariff in the near future, because the policy of overestimating demand will not change, and therefore the price of CSP will be determined by the most inefficient equipment.

In the author's opinion, it would be correct not to artificially overestimate the demand and price of CSP to increase investment attractiveness, but to give generating companies recommendations for a policy of disclosing the value of the company through greater openness, optimization of production processes and, at the expense of this money, carry out modernization and construction of equipment. While now supplier companies are not interested in this, and they spend all excess profits in various write-offs, thereby not revealing their market value, reducing the attractiveness for investors and reducing tax revenues to the budget.

References

1. Besser J.G, Farr J.G, Tierney S.F. The Political Economy of Long-Term Generation Adequacy: Why an ICAP Mechanism is Needed as Part of Standard Market Design // Electricity Journal. – 2002. – Vol. 15, Issue 7. – P. 53–62.
2. Cramton P., Stoft S. A Capacity Market that Makes Sense // Electricity Journal. – 2005. – Vol. 18, Issue 7. – P. 43–54.
3. URL: https://so-ups.ru/index.php?id=markets
4. URL: https://www.np-sr.ru/ru/market/wholesale/index.htm
5. Federal Law "On the Electric Power Industry" dated 26.03.2003 No. 35-FL.
6. Guidelines for design the development of power systems. (Approved by Order the Russian Federation Ministry of Energy dated June 30, 2003, No. 281). Moscow: RF Ministry of Energy, SO 153-34.20.118-2003.