Ensuring balance reliability in managing the development of electric power systems: condition, problems, information content

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Abstract. The paper is dedicated to the problem of ensuring balance reliability (BR) in the task of managing the electric power system (EPS) of a country at all times. The paper discusses the development and approval of methods for solving this problem. The stages of improving the methodological and model support of the balance reliability problem are considered. The authors review the main electric network and generating sources in recent years. The analysis of the developed and approved by the Russian Ministry of Energy and the impact of their application on the decisions made. The impetus for the development of BR tasks was the development of power systems: condition, problems, information content.

1 Introduction

The problem of ensuring balance reliability (BR) in the task of managing the electric power system (EPS) of a country at all times has been given due attention. By the end of the 20th century, BR deficiency was marked by accounting for the system failures due to emergency repairs. When several large generators go into emergency repair, the demand for electricity and the power of consumers can reach significant values (tens of GW), which necessitates the shutting down of several tens of days (unscheduled equipment repair).

2 Stages of improving methodological support.

The stages of improving the methodological and model support problem of balance reliability (BR) are considered. The authors review the main electric network and generating sources in recent years. The analysis of the developed and approved by the Russian Ministry of Energy and the impact of their application on the decisions made. The impetus for the development of BR tasks was the development of power systems: condition, problems, information content.
4.04% (MR 2003) to 6.8% in the amount of NRGC.

The analysis above results shows a significant increase in the regulatory reserve of generating capacity (NRGC), which was obtained, with the assistance of our institute, did not arrange the customer, especially in terms of the repair reserve and were significantly increased to them. The stages of the change are given in table. 1 (column 1 - the results of our institute, column 2 - correction of the energy network project, column 3 - proposals for correction from the EPS, column 4 - proposed by the Ministry of Energy for approval). Methodological instructions (MI) 2012 were not approved for many reasons. Basically, they concerned use old information base (there was simply no other information base available) and in the unreasonable overestimation of the repair component from 4.04% (MR 2003) to 6.8% in the amount of NRGC.

The analysis above results shows a significant increase in relation to the values NRGC in the 2003 MR, proposed with the EPS (22.18%, column 4) and in unreasonable MI in 2012 (20.5%, column 5). Basically, the overestimation is associated with the component of the power repair reserve, in offers from the EPS by 2.5 times, MI 2012 by 1.5 times. In the last two lines of the table. 1 shows the parameters of regulatory power reserve for CPS European and Siberian parts EPS of Russia in the procedure.

It can be seen that the differences in the values of power reserves are significant. During the CPS procedure, the value NRGC in the Siberian EPS increased due to possible restrictions on the energy supply of the hydroelectric power station, by another 8.55% [5]. At the same time, NRGC was not accepted 12, as in the MR 2003, but 17%. Given this, the increase NRGC for the CPS in the Siberian took a value of about 9 GW or 26.55%.

After the publication of this resolution with the EPS, the first attempt was pre-adopted aimed at forming new approaches to the justification level of reservation in the EPS, which is one of the components demand in the power balance. In 2011, the Institute Energosetproekt ordered a research [3] on the improvement, but outdated methodological recommendations (MR) 2003 [4]. The percentage of the regulatory reserve of generating capacity (NRGC), which was obtained, with the assistance of our institute, did not arrange the customer, especially in terms of the repair reserve and were significantly increased to them. The stages of the change are given in table. 1 (column 1 - the results of our institute, column 2 - correction of the energy network project, column 3 - proposals for correction from the EPS, column 4 - proposed by the Ministry of Energy for approval). Methodological instructions (MI) 2012 were not approved for many reasons. Basically, they concerned use old information base (there was simply no other information base available) and in the unreasonable overestimation of the repair component from 4.04% (MR 2003) to 6.8% in the amount of NRGC.

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Table 2.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Load schedule - December day</th>
<th>An hourly annual schedule</th>
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<tbody>
<tr>
<td></td>
<td>Taking into account the correlation</td>
<td>Excluding correlation</td>
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The purpose “Just...”, cause... factor leads to a significant increase in the value of the operational power reserve (9.99 and 6.86 %). The reduction in the percentage of the operational power reserve given in column 3 (6.86 %) in relation to the column 2, table 1 (8.97 %). This is due to a decrease in the average accident rate of generating equipment with 3.68 % [11] to today 2.77 %, a change in random load deviations from a given value and a factor in the availability of excess capacity relations. Recall that the results of the table 1 obtained with optimization of access capacities. The results of the table 2 show that taking into account the correlation dependence of the temperature leads to a significant increase in the value of operational power reserve (by 3.13 %). It should be noted that the customer overestimation of the repair component on 4.83 % (from 4.04 % (table 1) to 8.87 %) is leaning this increase. Given this, the value NRGC, obtained at the new information base, amounted to only 14.03 %.

Almost all worked out from 2012 to 2016 in the framework of the work with SO UPS on the methodological support of the BR task, including taking into account the territorial correlation of random changes caused by temperature fluctuations in one form or another, included in the national standard of the Russian Federation [6]. This can be attributed to the positive moments of the studies. It should be noted that the results of these studies were partially presented in the monograph [14] and work [15, 16]. Unfortunately, the studies of the ISEM SB RAS and ISEM SB RAS did not find understanding SO UPS and the Russian Ministry of Energy on the substantiated values normative power reserve. It can be assumed that this is why they did not become the basis for the development of new MI.
3 Analysis the new MI 2022 from the standpoint of ensuring balance reliability.

In the new MI, in accordance with the Federal Law “On Electro-Energy” No. 35-ФЗ dated 03/26/2003, a two-level planning model was adopted aimed at developing two software documents-a general scheme for the placement of electric power facilities and the development program (SDP) electric power systems of Russia. The substantiation of decisions to ensure BR in the development of these software documents, one way or another, is associated with the features of the EP power consumption mode and the methodological provisions of the estimate and provision of BR. Two chapters (V and VI) are devoted to these issues.

Power balances initially imply the presence of equality between the receipt (generation) and the consumable (consumption) of its parts. At the very beginning of the chapter, it is noted that when forming power balance sheets, a calculated reserve should be taken into account, the concept of which is not found in further points of this and subsequent chapters. Instead, the concept (paragraph 87) of the required power of power plants is introduced to ensure power balance (P_{required}). Its determination is carried out from the conditions for ensuring the regulatory indicator BR (P_{norm}) (paragraph 113). At the same time, it is quite obvious that the difference between P_{required} and the need value for power (P_{consumption}) (paragraph 82) is precisely the same calculated or NRGC. It should be emphasized that the concept of the required power is introduced only in the framework development (updates) the general scheme. For the development of SDP, this concept, as well as the concepts of excess and power balance, are completely ignored.

A distinctive feature of the new MI is introduction chapter “Ensuring Balance Reliability”. In previous editions of MI and MR BR, it was assured by the fulfillment of the requirements for the values NRGC of the territorial zones EPS. Their values were determined by multivariate calculations EPS and were given by the percentage maximum load [11]. New MI is aimed at developing managerial decisions as a result of calculating BR indicators in the form of a probability deficit work (ρ). It is important to note that the need to increase the territorial zones power reserves and accessories of bonds is required when developing both software documents (paragraph 115). At the same time, the solution of the issues ineffective generating capacities (paragraph 116) and their dismantling (paragraph 117) can only be resolved only when developing or updating the general scheme that are relevant for modern electric power.

In the new MI algorithms for decision-making on the justification required capacity (P_{required}) and, therefore, the territorial zones NRGC EPS did not undergo changes in relation to the MR 2003. This cannot be said about the methodology for solving the problem of evaluating BR indicators. Changes are mainly associated with increasing information security. It should be noted that almost all probability defined information used to evaluate BR indicators is formed and used only by SO specialists and is not available to the scientific community. The alleged public discussions of the adopted management decisions, in our opinion, will be ineffective due to lack of the entire spectrum of source information among interested parties.

4 Assessment impact of changes introduced into new MI in the accounting of initial information on decisions made

The changes should include new approaches to accounting: electrical consumption modes (paragraphs 97, B, 106), Kirchhof laws (paragraph 109), models the EPS calculation scheme (paragraph 98), random power deviations caused by the temperature factor (paragraph 106). The influence of these changes are tested and partially published [6, 14]. At the same time, which included in the new MI related to the issues of accounting for planned equipment repairs (paragraph 102) and the representation the power of renewable power plants, including the hydroelectric power station (paragraph 83, D, G) were not tested and, moreover, they were not published. Below is briefly a analysis the influence of information on decisions the development and dismantling of equipment.

**Presentation the power consumption mode.** In many publications [9, 14, 16], the influence of various submission of the power consumption regime on decisions made was shown. Recall that in the MR 2003 and in the 2016 work report (link 5), the power consumption mode was presented by one daily load schedule of the month that lasts a calendar year. In the new MI, as in the national standard, the power consumption mode is represented by an annual hourly load schedule (8760 hours).

The normative indicator BR for the reliability territorial zones EPS in accordance with the order the Ministry of Energy No. 321 (link 6) remains unchanged and, as in the old MR 2003, equal to ρ_{norm} = 0.996. For this indicator in the table. 2 (columns 4 and 5) include calculations the value of operational power reserve. As you can see, the values of power reserve are significantly different from the principles of accounting for the regime of electrical consumption used in the 2003 MR (columns 2 and 3).

**Model the estimated scheme EPS and taking into account the Kirchhof laws.** The new MI proposes use of a model with a large number of reliability zones than in the development of 2003 MR and with the condition implementation of both laws of Kirchhof when calculating randomly formed states of generating power. At the same time, throughput abilities are determined by restrictions on the transmission of power by sections obtained by calculation. Studies given in a number of publications [14] show sufficient discrepancies in assessing the regime when using different distribution of power deficiency (DPD) models. At the same time, when optimizing P_{required} these discrepancies become not so significant due to the possibility of redistributing generating power between reliability zones. Experimental calculations show that an increase in the reliability zones estimated EPS model can lead to an increase in
operational power reserve by a value not exceeding more than 0,5 percent of the maximum load (the number and denominator of the column 2 table. 1), accounting of both Kirchhoff laws maximum by 0,2 percent.

Accounting for scheduled equipment repairs. In the new MI, as in the 2003 MR, the disposition of the power reserve in terms of modern conditions for the functioning wholesale electric energy and power market and on amendments to some acts the Government of Russian Federation on the organization functioning wholesale electric energy and power market”

References
2. Decree the Government of Russian Federation No. 1172, December 27, 2010 (as amended on 01/19/2018) “On approval the rules of wholesale electric energy and power market and on amendments to some acts the Government of Russian Federation on the organization functioning wholesale electric energy and power market”
3. Methodological instructions for the design development of energy systems / OJSC Institute Energosetproekt, 2011, the “STC UPS” Section is approved. “Technical regulation in the electric power industry”, July 20, 2012, were not approved by the Russian Ministry of Energy.
5. Report on research work Comparative analysis of differences in distribution the compensation reserve of power between the EPS in regulatory documents of various years approval. / Syktvykar, 62 p. (2016)

5 Conclusion
10. Order the Russian Ministry of Energy No. 321 dated 04.30.2021. On the establishment of a regulatory level of balance reliability for the unified energy system of Russia, used in assessing the possibility of withdrawing generating equipment from operation.


18. Order the Russian Federation Government at December 30, 2022 N 4384

19. Order the Russian Ministry of Energy dated 02.28.2023 "On the approval SDP EPS of Russia".