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CONTROL SYSTEM FIDELITY OF ELECTRIC ENERGY

Introduction

To date, next situation has emerged. Tremendous efforts are put on reducing losses and rational use of electric energy both for traction of trains and for non-traction consumptions. Considerable practical experience is accrued and practical researches on a number of theoretical directions related to the reduction of specific electricity consumption are completed. We will name the reliability of such an account of electric energy, in which the value of the electric energy, measured by the appropriate accounting system, taking into account losses in the distribution networks and downstream transformers, differs from the actual value by no more than the value of the permissible error of the measuring system. The permissible error of the electric energy accounting system is determined by the parameters of the measuring complexes included in this accounting system, as well as the share of electrical energy, which is taken into account by each measuring complex. In fact, the question comes down to determining the actual and allowable imbalance, comparing them and providing recommendations.

Literature review

Imbalance resulting from inaccurate fixation devices balance components and the availability of costs that are not fixed devices. There are technical losses at the facility, the value of which is determined by calculation, and commercial losses arising from foreign influence [1, 2].

The issue of determining the causes of imbalances and reducing the level of excessive imbalances is devoted to a number of papers [3-5].

The actual imbalance of electricity during the accounting period is defined as the difference between total electricity consumption and the amount of electricity released (1). In percentages, the imbalance of electricity is determined in relation to the total electricity flow [8].

$$IMBac = \frac{Wr - Wo}{Wr} \cdot 100\% \qquad (1)$$

where $Wr\ (Wo)$ - the volume of electricity in the calculation period, is determined by the readings of the counters on the feeder.

The resulting imbalance is compared with the allowable and an appropriate conclusion is made about the presence of unreported electricity consumption at the substation and the presence of errors in the measuring complexes.

The allowable imbalance in feeder is determined by the formula (2) [8]:

$$IMBall = \sqrt{\left(\sum_{i=1}^{k} \delta_{ri}^2 \cdot d_{ri}^2 + \sum_{i=1}^{m} \delta_{oi}^2 \cdot d_{oi}^2\right)} \qquad (2)$$

where $\delta_{ri}\ (\delta_{oi})$ - mean square error of the i-th measuring complex, which corresponds to the precision classes of current and voltage transformers, and a counter intended for accounting for the electricity which receiving (output), which are included in this complex,%;

$d_{ri}\ (d_{oi})$ - the share of electricity which receiving (output) through the i-th measuring complex;

k - the number of measuring complexes that count the electricity received on the line-power busbar;

m - number of measuring complexes, which account for released energy (including for own needs of power plants).

Two concepts are considered as permissible unbalances. There are technically understandable imbalance of electricity (TUI), corresponding to the real conditions of operation of accounting devices, and regulatory imbalance of electricity (RIE), corresponding to "ideal" parameters and operating modes of measuring devices.

A summary statement on the receipt, processing and release of electricity is filled up monthly on each traction substation to determine the imbalance of electricity, the implementation of objective assessment and forecasting losses in the power supply facilities [6].

Electricity imbalances were calculated in [7, 8]. As can be seen, from July to January, the actual balance exceeds the allowable. One of the reasons is the underutilization of measuring transformers.

Today, the problem with accuracy of measurement of electric energy is quite acute. Nowadays exploited complexes operate in abnormal conditions, due to which their real errors are significantly higher than the errors, the corresponding classes of accuracy. One of the main reasons is measuring current and voltage transformers are exploited outside the limits of permissible GOST 1983 and GOST 7746 [9, 10] range of measurements of their nominal parameters, which leads to distortion of the readings of electricity meters.

The main reasons for the operation of measuring transformers outside the limits of GOST 1983 and GOST 7746 [12, 13]:

- change of the power of the load of the secondary circle. For example, when replacing inductive meters with electronic, the power consumption is an order of magnitude smaller, or with increasing the length of the lines of the measuring circle, which leads to a significant increase in load power;
- change in the power consumption of objects and the associated change in the magnitude of the primary current. For example, with a significant reduction (which is characteristic for the time being) or an increase in production volumes, transportation. For example, with a significant reduction (which is characteristic for the time being) or an increase in production volumes, transportation.

Approaches to improving the accuracy of electricity accounting are quite diverse. For example, in [14], if the errors of operation of measuring current and voltage transformers are systematic, it is suggested that these errors should be taken into account in the algorithms of calculation and accounting of Automatic system for commercial accounting of power consumption, adjusting the values of the measured currents and voltages.

Such an adjustment in Automatic system for commercial accounting of power consumption will avoid the requirements for increasing the accuracy class of measuring transformers in electricity metering systems. At the same time, a significant economic effect can be achieved both by increasing the accuracy of the Automatic system for commercial accounting of power consumption, and due to the fact that there is no need to replace the existing measuring transformers with devices with a higher accuracy class.

The problems of accuracy of electricity accounting in the Commonwealth of Independent States countries and in the west are solved in the following ways:

- replacement of measuring transformers on transformers with a lower value of the nominal load of the secondary circle;
- connection to the measuring range of the additional load.

In Europe, additional workloads in measuring circles are used, because it is much cheaper and more efficient [3]. However, for a measuring current transformer, the connection of the normal resistance is unacceptable, since in this case, angular errors increase. Because of this, Western manufacturers began producing various types of additional loads that do not increase angular errors

Formulation of the problem

To determine the nature of the imbalances of electrical energy it is necessary to analyze the sources and the nature of their origin. We divide the whole variety of imbalances into two groups. There are technical and economic.

The imbalance can also be attributed to the violation of the technology of transmission and distribution of electricity due to the growth of power losses (electricity) and voltage losses in the elements of the electrical network and, accordingly, the increase in voltage deviations on the clamps of the electrical receivers.

Actual power losses should not exceed regulatory, but in any case they lead to an imbalance between the received and distributed electricity. In accordance with the methodology for compiling the structure of the balance of electricity in electric networks 0,38-154 kV, the difference between actual and normative values of losses is called non-technical losses. Indeed, non-technical losses should include both unauthorized selection of electricity and additional technical losses due to a violation of the technology of transmission and distribution of electricity.

According to the materials of the Energy Strategy till 2030, due to the measures taken in 2006-2030 to reduce the technological costs of electricity in the networks, their volume should be expected in 2015 at the level of 9.8% of the total electricity supply to the network, in 2020 about 8.6%, in the year 2030 about 8.2%. By reducing the magnitude of the imbalance, it is possible to expect annual energy savings in 2030, as compared to the cost of 2005 in the amount of 25 billion kWh.

Additional (excessive) electric power losses in the supergrid and distribution networks lead to a decrease in the level of reliability of the electricity supplied to consumers and the need for additional

increase in load. Additional voltage losses lead to a violation of the normal quality of electricity (voltage). Such a violation can be characterized as a imbalance of voltage losses, which, in turn, negatively affects the resonance of production schedules and electricity consumption.

In addition to the imbalance of power and voltage losses of electric networks, market participants are faced with technical imbalances associated with accounting for energy resources that are mined, produced, processed, transported, stored and consumed.

Therefore, their production and consumption, in particular electric and thermal energy, must necessarily be equipped with metering systems of commercial accounting, which have minimal technical errors of measurements. In the process of implementing commercial accounting it turns out that a number of market participants, mainly consumers, have limits of balance sheet belonging to the elements of the network that are not included in the calculation scheme.

Hence, there is a need to "bring the declared loads" of market participants to the nodes of the calculation scheme in the planning of prices and volumes of commodity products, as well as the need to "bring actual load capacities" units of the calculation scheme to the actual load of market participants.

Consequently, the most probable necessary and sufficient condition for the technological completeness of the commercial accounting system of the wholesale market entity is the placement of measuring complexes on the boundary of the balance sheet of its electrical network. Auxiliary in solving the accounting problem of electricity is the introduction of the Automatic system for commercial accounting of power consumption.

Only the Automatic system for commercial accounting of power consumption with operational remote collection and automatic processing of the results of this collection can effectively solve the balance problem, determine the imbalance and identify the losses of electricity.

For reliable and prompt solving of balancing tasks, it is necessary to minimize the use of old calculation methods based on statistics and, conversely, to develop methods for calculating the balance, based on direct measurements within the framework of the Automatic system for commercial accounting of power consumption.

Conclusions

The authors will create a three-level system for monitoring the reliability of electricity metering at transformer substations. We will solve the corresponding tasks at each of the levels.

The system of the first level is created at the points of reception of the electric power. For each item a passport shall be filled in which all inputs and removable feeders, stamps, numbers and coefficients of transformation of measuring complexes for the reception and return of active and reactive energy are indicated.

The control of the accuracy of accounting is carried out by comparing the actual imbalance of accepted and distributed electricity with a permissible value on a monthly basis. If on the basis of the month the non-equilibrium of electronegativity at any point of admission exceeds the permissible value, then it is necessary to conduct a revision of the accounting system of this point of reception in the conditions of operation.

The second level is organized at the level of control zones. Information about such a zone can be divided into constant and variable. The constant information is the scheme of the monitored zone, which specifies the power source, the mark and the length of the feeding wires and cables, as well as the place of the installation of electrical energy meters.

Variable information includes indicators of meters, electric power losses in power lines, as well as losses in downstream transformers at those substations where the meter is installed on the low side.

The third level of control over the reliability of accounting is determined by the imbalance between the electricity received by inputs and distributed by the feeders of the transformer substation. If there is no account for 0,4 kV feeders, the balance of the accepted and distributed energy is made up of inputs of the substation and consumers. Losses in reducing transformers are taken into account when compiling the balance in the case when the meters of the electronic energy at the substation inputs are installed on the high voltage side.

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It is difficult to install consumers with faulty accounting systems, to discover areas of distribution networks with increased technological losses, and the place of theft of electric energy. To develop a methodology that allows, with existing accounting systems, to increase the informativeness of the component of the difference of distributed and consumed energy with virtually no additional expenses and, in the presence of an automated accounting system, to refuse periodic verification of the measured measuring devices and current and voltage transformers. The system for monitoring the reliability of electrical energy accounting at transformer substations has been further developed, which breaks the task at a level and solves them in stages. The developed system allows abandoning the periodic calibration of measured accounting devices and current and voltage transformers.

Keywords: electricity accounting; imbalance; actual imbalance; allowable imbalance; control system; counter; losses.

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СИСТЕМА КОНТРОЛЮ ДОСТОВІРНОСТІ ОБЛІКУ ЕЛЕКТРИЧНОЇ ЕНЕРГІЇ

Важко встановити споживачів з несправними системами обліку, виявити ділянки розподільчих мереж з підвищеними технологічними втратами, місця розкрадання електричної енергії. Необхідно розробити методику, що дозволяє при існуючих системах обліку практично без додаткових витрат підвищити інформативність складової різниці розподіленої та спожитої енергії та при наявності автоматизованої системи обліку відмовитися від періодичної повірки вимірюваних приладів обліку та трансформаторів струму та напруги. Отримала подальший розвиток система контролю достовірності обліку електричної енергії на трансформаторних підстанціях, що розбиває задачу на рівні та вирішує їх поетапно. Розроблена система дозволяє відмовитися від періодичної повірки вимірюваних приладів обліку та трансформаторів струму та напруги

Ключові слова: облік електроенергії; небаланс; фактичний небаланс; допустимий небаланс; система контролю; лічильник; втрати.

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СИСТЕМА КОНТРОЛЯ ДОСТОВЕРНОСТИ УЧЕТА ЭЛЕКТРИЧЕСКОЙ ЭНЕРГИИ

Трудно установить потребителей с неисправными системами учета, выявить участки распределительных сетей с повышенными технологическими потерями, места хищения электрической энергии. Необходимо разработать методику, позволяющую при существующих системах учета практически без дополнительных затрат повысить информативность составляющей разницы распределенной и потребленной энергии и при наличии автоматизированной системы учета отказаться от периодической поверки измеряемых приборов учета и трансформаторов тока и напряжения. Получила дальнейшее развитие система контроля достоверности учета электроэнергии на трансформаторных подстанциях, которая разбивает задачу на уровни и решает их поэтапно. Разработанная система позволяет отказаться от периодической поверки измеряемых приборов учета и трансформаторов тока и напряжения.

Ключевые слова: учет электроэнергии; небаланс; фактический небаланс; допустимый небаланс; система контроля; счетчик; потери.

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