P. D. Lezhniuk, Dc. Sc. (Eng.), Prof.; V. Yu. Prokhvalitov; G. D. Kraskovskiy

INFORMATION SUPPORT OF THE CONTROL AND MONITORING OF ADDRESSED ENERGY FLUXES IN ELECTRIC NETWORKS

The paper considers problems of increase of technical-economic efficiency of electric networks operation in conditions if balancing marker and bilateral agreements on energy supply as a result of improvement of information support.

Key words: *electric networks, energy fluxes, energy losses, information support.*

Introduction

One of the main conditions of business-processes realization of electric systems operation modes control, including the control of addressed energy fluxes, is high-quality information regarding networks states monitoring of energy fluxes, in condition of bilateral agreements and balancing electric energy market puts forward a number of requirements regarding technological information, cause by the necessity to control and compensate in the rate of disbalance process, technological losses of electric energy, determining their address, as well as react on internal and external disturbances. All this can and must be performed in conditions of localized control observing basic principles of centralized control in order to achieve system effect [1-3].

Technical-economic efficiency of transmission and selling system operation depends on completeness and accuracy of information. Part of needed information is data flows of the objects of control regarding their state and operation modes (sate of switching facilities, values of voltage, power, etc.). Processing of arriving information is performed in real-time mode, that is why, the quality of decisions, taken by the dispatcher and conditions of automatic systems operation depend on the reliability and performance of information systems, realizing the given functional. Another part of the information is flow of data needed for realization of long-term and short-term planning of modes, coordination of maintenance. These types of information are not of monitoring character, but accuracy of optimization and decision taking regarding on-line control (monitoring) and power fluxes control in electric networks depend on this information.

The given paper considers problems, dealing with the increase of efficiency of electric networks functioning in conditions of addressed energy supply, electric energy transits as well as their information support.

Determination of electric energy losses, caused by addressed fluxes

Nowadays the ways of this problem solution are considered in numerous publications, losses caused by address and transit transfers are suggested to determine by different methods. In [2] these losses are proposed to determine by means of linearization of balances modes, calculated for the set time cuts, with further application of overlapping method. Such an approach enables to determine the sources, electric energy is transmitted to the given node (load) and the volume of this energy.

In fact, the problem of determination of energy losses as a result of transit transfers is the problem of determination of corresponding components of losses in the branches of the system, along which transit energy is transmitted. In [2] it is shown that loses in system branches, depending on the power in system nodes, are determined:

$$\Delta\dot{\mathbf{S}}_{\mathbf{в}} = \dot{\mathbf{A}}_{k}\dot{\mathbf{S}} + \Delta\dot{\mathbf{S}}_{nb}, \qquad (1)$$

where $\dot{\mathbf{S}}$ – is a vector of powers in nodes; $\dot{\mathbf{A}}_{k}$ – is the array of distribution coefficients of power losses in the branches of electric networks, depending on powers in the nodes, taking into account transformation factors of coupling transformers; $\Delta\dot{\mathbf{S}}_{nb}$ – is vector-column of power losses in the branches of the circuit due to e. m. f. of unbalances transformation factors.

In (1) each row of arrays $\dot{\mathbf{A}}_k$ and $\Delta\dot{\mathbf{S}}_{нб}$ is determined:

$$\dot{\mathbf{A}}_{ki} = (\dot{\mathbf{U}}_t \dot{\mathbf{M}}_{\Sigma ki})\widehat{\mathbf{C}}_{ki}\dot{\mathbf{U}}_d^{-1};$$
$$\Delta\dot{\mathbf{S}}_{nbi} = (\dot{\mathbf{U}}_t \dot{\mathbf{M}}_{\Sigma ki})\widehat{\mathbf{D}}_{bi}\widehat{\mathbf{U}}_b, \quad (2)$$

where $\dot{\mathbf{A}}_{ki}$ – is vector-raw of the array of distribution coefficients on the losses for i-th branch of the circuit on the power in its nodes, taking into account complex transformation factors; $\Delta\dot{\mathbf{S}}_{nbi}$ – are losses in i-th branch due to e. m. f. Of unbalanced transformation factors of coupling transformers ; $\dot{\mathbf{U}}_t$ – is transposed vector of voltages in nodes; $\dot{\mathbf{M}}_{\Sigma k}$ – is the array of branches connection with nodes, taking into account transformation factors; $\dot{\mathbf{U}}_d$ – is diagonal matrix of voltages in nodes; $\widehat{\mathbf{C}}_k$ – is adjoin matrix of current distribution, taking into account transformer couplings; $\widehat{\mathbf{D}}_b$ – is adjoin matrix of conductivities, forming balancing currents from unbalance transformation factors in closed loops of ES; $\widehat{\mathbf{U}}_b$ – is adjoin vector-column of voltages in balancing nodes.

It should be noted, that losses distribution coefficients depend on the values of voltage in nodes, which are determined by loads of generation in circuit nodes, as well as circuit parameters, which, with certain assumptions, are assumed to be constant, but in fact, they are not constant, since depend on these factors allows to state , that nonlinearity of losses dependence on mode parameters in the model (1) – (2) remains.

Two variants of energy losses calculation are possible: when permanent monitoring of losses according to telemeasurement data is carried out, and when calculations of energy losses are carried out during period T using load graphs characteristics. In the first variant, while changes of ES modes, it is necessary to recalculate the array of coefficients of losses distribution in branches, because the values of its elements depend on the voltage in nodes. The latter condition can be realized, if certain level of on-line-information complex (OIC) ES as well as ASDC hardware and software is achieved. Recalculation of matrix $\dot{\mathbf{A}}_k$ depends on required accuracy of losses in branches $\Delta P_в$ and, in particular, in the set branches.

In another variant calculation of power losses for the mode of maximum address transfer ΔP_{max} or for average power value, transferred to the i-th load in accordance with agreed schedule, $\Delta P_{av.}$ is carried out. Energy losses, caused by addressed flows ΔW for T period are determined by the formula:

$$\Delta W = \Delta P_{max}\tau, \quad (3)$$

$$\Delta W = \Delta P_{av.} T\, k_f^2, \quad (4)$$

where τ – is number of hours of the largest addressed losses; k_f^2 – coefficient of load graph form of i-th load, for which its participation in total losses is determined.

In the first case, to make use of the formula (1), for losses determination, we should know matrix $\dot{\mathbf{A}}_k$, which is determined by the results of stable mode calculation. To perform the corresponding computations we need volume of information. This information is formed in MIC data base. In the second case, in (3) and (4) ΔP_{max} and $\Delta P_{av.}$ are also determined by the results of stable mode calculation. For determination of τ and k_f^2 we should know the planned schedule of power consumption and real schedule deviation. Real schedule of power consumption in conditions of balancing market may considerably differ from agreed schedule [4]. Thus, error of energy losses determination depends on the accuracy of ES parameters and its mode parameters, as well as energy consumption conditions. For monitoring and optimum control and addressed power flow in electric networks of energy systems and evaluation of addressed losses of electric energy we should develop and improve the existing information support.

Automatic control system of energy account (ACSES) of local level as the element of energy balancing system

The aim of ACSEA improvement is the formation of transparent relations between procedures, suppliers and consumers of electric energy. Proceeding from this the main tasks to be carried out by ACSEA of local level are to provide the account of active and reactive electric energy on the boundaries of balance belonging of electric networks, as well as improvement of accuracy, reliability and efficiency of data obtaining regarding generation, transmission and supply of electric energy [5]. Realization of these tasks enables to increase the efficiency of electric networks modes operation and perform monitoring of all the components of electric energy balance to elaborate measures aimed at their optimization.

The structure of ACSEA tasks is regulated by regulatory documents [5] and defined functional structure of the system, that, in general, consists of measuring environment, subsystem of collection and processing of data, as well as communication environment (fig. 1).

List of requirements to functional elements of ACSEA (fig. 1) concerning their reliability, validity of initial information is composed [5, 6]. Special requirements concern the accuracy of measuring environment, namely: classes of accuracy of measuring transformers, primary converters and meters [6]. At the same time, for ACSEA of local levels the time, for ACSEA of local levels the list of requirements and recommendations list of requirements and recommendations regarding the volume and intervals between up-dating of information, i.e. formation of measuring environment, necessary for solution of functional problems, connected with making up of electric energy balance and ES mode control is practically missing.

As this problem has not been solved yet, as well as it is practically impossible to provide complete observation of ES, hence the development and implementation of ACSEA and its efficient functioning is rather complicated task.

As a result, practically it is impossible to analyze the structure of electric energy balances, since information support allows (with certain accuracy) to determine only overall expenditures of electric energy. Thus, elaboration of measures aimed at reduction of separate components of overall energy losses (technical, commercial losses, etc.) in practice is complicated, and sometimes impossible task.

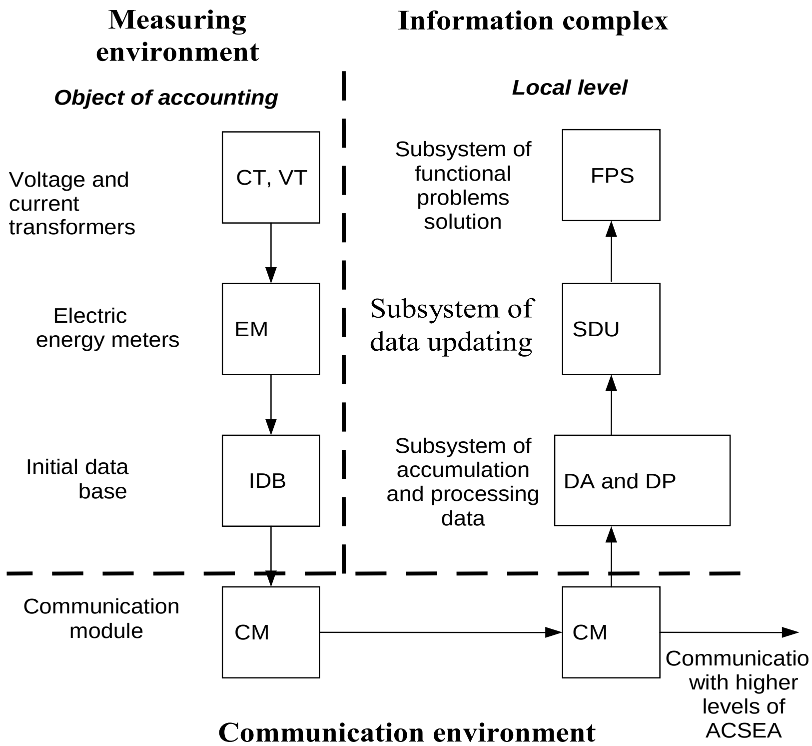

Fig. 1. Functional diagram of ACSEA

The necessity of account of network parameters, change for improvement of monitoring efficiency and electric energy

New possibilities of existing technologies enable to make a transition to higher efficiency of control and maintenance of electric networks within the frame balancing market due to monitoring of statically real values regarding the parameters of the environment, which considerably influence the short-rearm forecast of energy consumption, energy losses in the elements of networks and systems, etc. For this purpose the system of meteodata collection (SMS) must be used. Data of meteorological observations, formed in corresponding data base, provide their analysis, evaluation and forecast of weather conditions.

In [7] the structure of administration system of meteorological parameters collection, based on the information from meteorological posts of the substations is suggested. The efficiency of the suggested system, which is used for specification of ES parameters, is proved by the experience [8]. For instance, specification of data regarding active resistance of over-head transmission lines allows to define more accurately losses in electric networks. Table 1 contains, as an example, the results of power losses calculation in Dneprovskiy electric networks, without taking into account and taking into account variations of active resistances of the lines caused by temperature increase.

Table 1

Losses of power in electric networks

Mode	Feed (supply) P, MWt	Supply (sell) P, MWt	Total losess P, MWt	Losses in ETL 750-330 кV, MWt	Losses in ETL 220-35 кV, MWt	Losses in transformers, MWt
Initial	7063,1	6962,5	100,6	62,1	17,1	21,4
Increase of active resistance of ETL by 5%	7065,8	6962,4	103,4 (+3%)	63,3 (+2%)	18,7 (+9%)	21,4

As it is seen form Table 1 non-account of only active resistance variation, depending on weather conditions results in significant errors while determination of power losses in electric networks. Due to this reason greater error is observed in the networks of lower voltage. In the networks of 330 kV and higher, where the corona losses and determining, the influence of active resistance variation on losses calculation error are manifested in less degree. In these networks the account of weather conditions is necessary for more accurate determination of corona losses, especially along route.

To obtain the desired effect while optimization of electric networks operation, all influencing factors must be taken into account, including telemeasurements errors for more accurate mode calculation and, correspondingly, performing optimization measures. Observability and controllability of the system are of great importance for performing optimization impacts.

While determining of power losses telemeasurements errors (S, P, Q, U ,etc.) in the node may be within range 0 до ±5%. For determination of any parameters of telemeasurements everything is reduced to load (generation) determination in the node. Thus, evaluation of telemeasurement error influence can be compared to the variation of load in the node, i.e., to minor disturbance in ES.

First the calculation is performed without taking into account telemeasurement errors. After calculation of stabilized mode the algorithm provides determination of the matrix of current distribution coefficients $\dot{\mathbf{C}}$ and matrix of losses distribution coefficients $\dot{\mathbf{A}}$. After the formation of coefficients matrix power losses in the given branches from the given nodes are determined. After that the correction on initial data is performed, taking into account telemeasurement errors and another calculation is performed, that allows to determine the influence of telemeasurement error on power losses in the given branches or nodes. The influence of telemeasurement error we consider as new operation of ES:

$$\delta\dot{S}_i = \dot{\mathbf{T}}_i^k \dot{\mathbf{S}}^k - \dot{\mathbf{T}}_i^{k+\Delta} \dot{\mathbf{S}}^{k+\Delta},$$

where $\dot{\mathbf{S}}^{k+\Delta}$ – is power variation in the node, taking into account telemeasurement error or taking into account that $\dot{\mathbf{S}}^{k+\Delta} = \dot{\mathbf{S}}^k + \delta\dot{\mathbf{S}}$, and $\delta\dot{\mathbf{T}}_i = \dot{\mathbf{T}}_i^k - \dot{\mathbf{T}}_i^{k+\Delta}$, the error of power losses determination in circuit branches on telemeasurements error will be

$$\dot{\mathbf{\Pi}}_{S_g} = \delta\dot{T}_i \dot{S}^k \text{ - } \delta\dot{S}\dot{T}_i^{k+\Delta},$$

where $\dot{S}^k$ – is power in ES node, without taking into account telemesurement error; $\dot{\mathbf{S}}^{k+\Delta} = \dot{\mathbf{S}}^k + \delta\dot{\mathbf{S}}$ – is power in ES node, taking into account telemeasurement error; $\dot{T}$ – is matrix of power losses distribution coefficients in the branches of the circuit, depending on power in nodes.

If measurements were performed only in one node – g-th then the initial of power losses in i-th branch, taking into account telemeasurement error in g-th by $\delta\dot{S}_g$ will be

$$\delta S_{ig} = \mathbf{\Pi}_{t_{ig}} \delta S_g .$$

Power losses sensitivity coefficient in i-th branch is determined from telemeasurements error in g-th node

$$\mathbf{\Pi}_{t_{ig}} = \frac{\delta S_{ig}}{\delta S_g} .$$

Further the reverse problem can be solved. As a result of improvement of information support new admissible error (less than previous one) is established and corresponding error of loses calculation. By the difference of previous and values of loses we judge about the efficiency of investments in the system of information support.

Conclusions

Development of information systems, being important factor of enhancement of monitoring and technological control systems, must be considered not only as important organizational and engineering problem, but also as economic task of paramount importance. To provide observability and controllability of addressed power flows we must improve both hardware and software components of information support.

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Lezhniuk Petro – Doctor of Science (Eng) Professor, Head of the Chair of Electric stations and systems.
Vinnytsia National Technical University.

Prokhvalitov Volodymyr – Technical Director of Utility Company "Khartep".

Kraskovskiy Georgiy – Master, Department of Energysupply.
National Technical University "KPI".