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OPTIMUM LOAD DISTRIBUTION BETWEEN POWER PLANTS IN THE CONDITIONS OF ENERGY MARKET

In the work the problem of the optimum load distribution of the electric power system between the electrical stations is investigated. The new criteria of the optimum distribution of the resistive load between the electrical stations under the contemporary market conditions are proposed. Is examined approach, which makes it possible not only to determine the optimal solutions for the specific subjects of the wholesale market for the electric power of the Ukraine, but to form the optimum technical and economic conditions of their joint functioning with the use of predominantly economic levers and technical limitations.

Key words: *electric power system, electrical station, the optimization of load distribution, the criterion of optimum, bulk tariff on the electric power, the analysis of the sensitivity of power losses*

Introduction

The advent of the first power stations and unified electric energy systems caused the problem of their operation models optimization. One of the basic problems of optimum control of electric energy system (EES) in normal operation conditions is optimal load distribution between power plants (PP) and their units operating in parallel. With EES development, complexity of its technical and administrative structure the number of optimization problems and, accordingly, optimization methods of operation modes of power stations and electric energy systems has increased [1]. Proceeding from this fact the problem of automation of the basic functions of dispatcher control of EES became especially actual.

Since 1996 the wholesale market of electric energy (WME) was created in Ukraine. The basic idea of WME creation envisaged regulating at the expense of competition tariffs for electric energy which is delivered by separate units. The National Commission on electric power industry regulation (NCEIR) developed and adopted standard baseline according to which utility companies calculate retail electricity rates on basis of the market formula which contains the following components:

- wholesale market price;
- tariff which compensates costs on electric energy transmission;
- tariff which compensates costs on electric energy supply.

Introduction of uniform retail electricity rates has led to some negative factors regarding utility companies, namely:

- utility companies have no stimulus to optimization of electric energy supply schedules with the purpose to decrease costs on its procurement;
- utility companies have no stimulus to decrease of electric energy losses in electrical grids [2].

Along with new economic conditions in which power industry operates, with the advent of electric energy wholesale market the statement of problem, criteria, methods and optimization means have also changed. As a result of transition to market tariffs formation for electric energy criteria of optimal functioning are different for separate subjects of WME, and often controversial [1]. Earlier, in the period of centralized control of electric power industry, the basic optimization criterion was minimization of fuel expenses for electric power generation and cost price of produced energy. Now, in market conditions the traditional problem of optimization is divided into a number of subtasks. Criterion of maximum profit from energy sale or minimum of expenses for power resources needed for generation, transformation, transmission and distribution of electric and thermal energy are determining for them. A criterion of price minimum also remains very important [3-7, 10].

In [10] it is noted, that changes in the structure and management organization in this branch

which have taken place for last ten years, require revising of approaches to management optimization. Therefore there is a task of new methods search of the problem solution, choice of new optimization criteria. Proceeding from the above-mentioned, the given work is devoted to formation of new conditions and criteria of optimum distribution of active load between power plants in modern conditions.

The choice of optimum composition of units has great influence at the stage of short-term optimization of EPP modes. If we make an assumption that interests of separate EPP subjects are common the problem can be formulated as follows [5]: system with S in parallel by operating thermal power plants is set and their total load is P_{Σ} . It is necessary to distribute the load between power stations so that a total fuel cost (or total expenses of equivalent fuel) was minimum under condition of covering set for each moment of load time. Taking it into account the optimization problem is formulated:

To minimize

$$Z = \int_0^T \sum_{s=1}^S Z_s = \int_0^T \sum_{s=1}^S u_s B_s(P_s) \Rightarrow \min, \quad (1)$$

Under the condition

$$\sum_{s=1}^S P_s - P_{\Sigma} - \pi = 0, \quad (2)$$

Where $B_s(P_s)$ - metering characteristic of S^{th} thermal station; u_s - cost of one ton of fuel at S^{th} station; P_{Σ} - total EPP load for S stations group of set utility company; π - electric power losses in electric grids of EES, caused by group influence of S stations.

Solution of the problem (1) can be obtained by determining conditional extremum using Lagrange method. But disadvantages of such method which consist in impossibility of direct account of technical restrictions and complexity of mathematical representation of optimum solution, make its application for operating problems and complex optimization of normal modes of electric power systems unreasonable [6, 8, 9].

For determination of optimum load distribution between power plants it is possible and reasonable to use the conditions of optimality formulated in [8], that is distribution by r-equivalent EES circuit.

Load distribution between PP by economic resistances

If fuel component of charges on electric power generation of S^{th} EP (at classical statement of load distribution problem) is substituted by active resistance R_{es} , losses of electric energy in which to equate to the given component of charges on electric power generation for the same period T , then while operation of the station at constant load in T period we can write:

$$Z_{Ree} = Z_{Bs},$$

$$Z_{Ree} = c V_s T = u_s B_s(P_s) T, \quad (3)$$

Where c – wholesale tariff for electric energy, V_s – equivalent active power losses in resistance R_{es} due to power overflows from S^{th} station $P_s / \cos \varphi_s$.

Value of equivalent active power losses (assuming, that $\cos \varphi_s = \cos \varphi_{nom}$) is calculated by the formula:

$$V_s = \frac{P_s^2}{\cos^2 \varphi_{nom} \cdot U_s^2} \cdot R_{es}, \quad (4)$$

Proceeding from this

$$3_{Res} = c \frac{P_s^2}{\cos^2 \varphi_{nom} \cdot U_s^2} \cdot R_{es} T. \quad (5)$$

It is obvious from the solution (3) and (5), that economic resistances of stations are nonlinear functions of their expense characteristics, generated power and node voltage U_s and for classical problem of load distribution between PP are calculated by the formula:

$$R_{es} = \frac{B_s(P_s) \cdot U_s^2 \cdot \cos^2 \varphi_{nom} \cdot u_s}{c \cdot P_s^2}. \quad (6)$$

If we present power plants in equivalent EES circuit by their economic resistances (6), that is to take into account their economic characteristics, the problem of profitability of EES operation will be reduced to the problem of optimization of flow-distribution by the criterion of active power losses minimum for some moment of time:

$$\begin{aligned} V_{\Sigma} &= \sum_{s=1}^S 3R_{es} J_s^2 \Rightarrow \min; \\ \sum_{s=1}^S P_s - P_{\Sigma} - \pi &= 0, \end{aligned} \quad (7)$$

Where J_s - modulus of S^{th} power station current at present moment of time which flows along the branch R_{es} .

The latter, according to [8], for EES of random configuration is solved by means determination of current-flow distribution in r-equivalent circuit by any known method. Optimum load of S^{th} power station is calculated by the expression

$$\dot{S}_s = \sqrt{3} \dot{U}_s \hat{J}_s, \quad (8)$$

Where $\hat{J}_s$ - complex-conjugate current, flowing in branch R_{es} of equivalent r-circuit of EES.

Load distribution between PP in modern conditions of energy market

As it was stated above, the statement of optimization problem of EES operation modes and optimization criteria change in modern conditions.

Integrated functional structure of wholesale market of electric energy can be presented as Fig. 1.

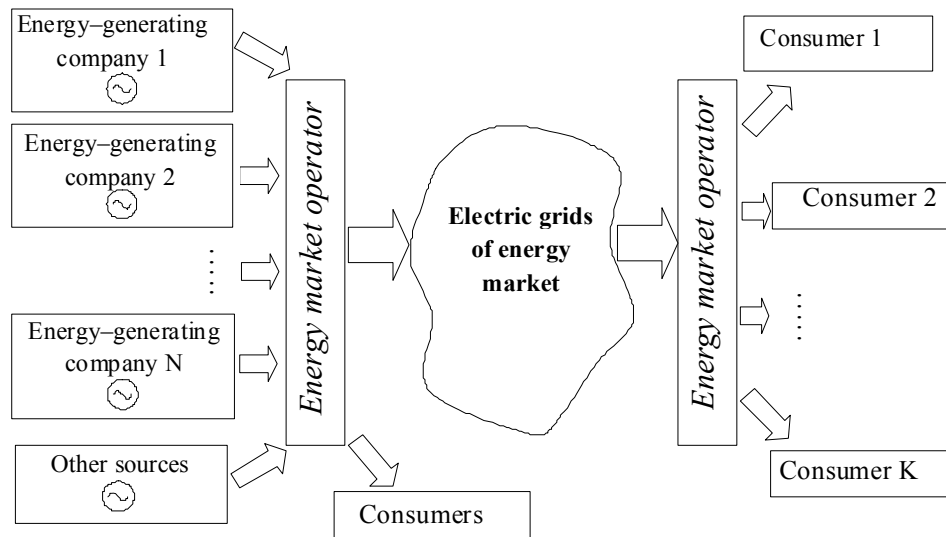


Fig. 1. Integrated functional structure of wholesale market of electric energy of Ukraine

In the structure we can distinguish energy-generating companies (EGC), performing the control and maintenance of different types of power plants. They supply electric energy at WEM at certain tariff u_{EGC_i} through operators, actually supplying it in electrical grids of power market (system-supporting grids). Electric power consumers both powerful users and regional power companies, buy electric power at WEM via operators at tariff for consumers u_{CON_i} , actually obtaining it from electric grids of WEM. Other energy sources (small HPS, Wind Power Plants and other nonconventional energy sources) via operators, utilizing or renting electrical grids of regional power companies and powerful consumers, can sell generated electric energy at energy market or sell it directly to separate consumers at wholesale or another tariff u_{ID_i} .

Now actually all above-mentioned electricity tariffs for electric energy u_{EGC_i} , u_{CON_i} , u_{ID_i} are determined by single wholesale tariff of UFR u_{WM} . In the assumption, that $u_{\text{EGC}_i} = u_{\text{WM}}$ and neglecting nonconventional energy sources influence (because of their insignificant share in total generation of electric energy) the problem of optimization of load distribution between power plants can be solved in the following manner.

If stations, remaining the elements of EES in electrotechnical sense, are the subject of independent management then medes optimization of EES can be carried out by the criterion of expenses minimum for energy 3_E supplied by stations taking into account losses in energy market grids. Unlike (1), the problem of optimal load distribution between stations is formulated:

$$3_E = \int_0^T \sum_{s=1}^s P_s \beta_s dt \rightarrow \min, \quad (9)$$

Where β_s – cost of 1 kWt/h of electric energy supplied from buses of S^{th} station.

Having performed the conversion analogously to the above-mentioned, at the same assumptions we arrive to the same conclusions. Difference is only that economic resistances, according which stations are arranged, are calculated by the formula:

$$R_{es} = \frac{U_s^2 \cos^2 \varphi_{nom} \beta_s}{c P_s}. \quad (10)$$

Proceeding from above-mentioned, load distribution optimization between PP can be carried out by specifically technical and operating conditions only for the case when cost of supplied energy from buses of all S stations, and also cost of electric power losses in electrical grids of WEM correspond to wholesale tariff for electric energy $\beta_s = c = u_{\text{WM}}$, since then

$$R_{es} = \frac{U_s^2 \cos^2 \varphi_{nom}}{P_s}. \quad (11)$$

For present situation it is necessary to consider also economic aspects of separate WEM subjects functioning. In this case fuel expenses and other maintenance charges at each station become secondary, and electricity tariffs for separate energy generating companies, and also tariffs for separate consumers become major issues.

Let's assume that electric power sale occurs via WEM operators on the basis of price requests of suppliers (EGC) and consumers. Requests for next days contain schedules by the hours of necessary consumed electric energy and reasonable generation for ES. For each consumer price is specified which he agrees to pay for electric energy, and for each energy generating company minimum cost price for electric power is specified.

Under such conditions for each time T function of aim for solution of the problem of WEM peak efficiency supply will be written in the following form [11]:

$$3 = \left\{ \sum_{i=1}^N \left[\sum_{s \in M_i} P_s \right] u_{\text{EGC}_i} - \sum_{j=1}^K P_{\text{CON}_i} u_{\text{CON}_i} \right\} T \Rightarrow \min, \quad (12)$$

Under the condition

$$\sum_{i=1}^N \left[\sum_{s \in \mathbf{M}_i} P_s \right] - \sum_{j=1}^K P_{CON_i} - \pi = 0, \quad (13)$$

Where N – quantity of energy generating companies presented at energy market and exercise PP control from the totality $\mathbf{M}_i$ which generation is subject to optimization according to technical restrictions; K – quantity of consumers which obtain electric energy at WEM at price requests; π_{EGC_i} – price of 1 kWt/h of supplied energy of i^{th} energy generating company, P_{CON_i} – ordered electrical output of i^{th} consumer during period T ; π_{CON_i} – price of 1 kWt/h of electric power for i^{th} consumer.

Electric power transmission by EES grids is connected with certain losses of electric power. Magnitude of losses is insignificant (3-7 %) as compared with the magnitude of total generation or consumption, but, its cost is commensurable with the difference in (12). Therefore the set criterion function should be specified:

$$Z = \left\{ \sum_{i=1}^N \left[\sum_{s \in \mathbf{M}_i} P_s \right] \pi_{EGC_i} - \sum_{j=1}^K P_{CON_i} \pi_{CON_i} + \pi_{WEM} \right\} T \Rightarrow \min, \quad (14)$$

For independent variables for solution of the problem (12), (13) it is possible to accept only ES powers P_s from the totality $\mathbf{M}_i$, or additionally the prices for electric power π_{EGC_i} and (or) π_{CON_i} . In the first case the problem (12), (13) is reduced to the problem (9) and its solution is carried out in the same way.

At presence in the list of independent variable prices for electric energy the problem becomes rather complex. Values of the prices for electric energy can be constant during certain time or variable according to modes of EES operation. Electric power produced by nonconventional energy sources can be sold at separate tariffs (principle of "green" tariff). The prices for electric energy for consumers also can change from floor price which offers them WEM, to maximum which they agree to pay for electric energy. Proceeding from the above-mentioned, for the solution of the problem (12), (13) taking into account economic levers it is reasonable to use the methods of sensitivity analysis [12].

Requirements to effective formation of WEM tariffs

Above-mentioned powerful lever of providing the efficient operation of energy market is determination of objectively proved electricity rates for separate energy generating companies and consumers. Magnitude of tariff should consider standard expenses on generation (distribution) of electric energy, and also influence of separate subjects on modes of operation and electric power losses in backbone grids. Such approach will provide the main goal of WEM creation - the organization of equal conditions of competition for separate energy generating companies, and also encouragement of consumes to optimization of their functioning.

For separate energy generating companies the price for electric power delivery can be varied over the range from π_{EGC_min} to π_{EGC_max} , and value π_{EGC_min} should provide standard overall performance of company, taking into account interests of investors. Value of range should be determined proceeding from the measure of power plants influence of separate EGC on efficiency of functioning of power market, that is, based on (14), their influence on profitable component of the balance, and also on losses connected with electric power transmission.

According to existing methods only the latter factor leads to correction of the price within 15-20 % that is reasonable enough, especially for EGC, providing function of thermal PP, and also separate energy sources of low power. In this case the price for electric power should be corrected, proceeding from real (or approached to them) values of transit losses caused by electric power transmission from separate PP.

Redundancy losses in backbone grids should not be included into procurement and cost prices for electric power as it leads to absence of administrative structures interest in raise of WEM

function efficiency by means of technical arrangements (renovation of main equipment, development of automation means of monitoring systems and control, etc.). For formation of efficiency parameter (14) it is necessary to use minimum possible from technical point of view the value of power losses π (considers losses from inherent and mutual overflows) which can be determined on the basis of r-equivalent EES circuit.

The analysis of sensitivity of mutual and transit power losses in EES

In [12] it is noted, that active-power losses in electrical grids of EES exercise influence on load distribution between energy sources, consumption parameters, transformation ratios, and also mutual and transit overflows of power.

Total power losses in branches for set mode of EES operation can be calculated by the formula [12]:

$$\Delta \dot{\mathbf{S}} = \dot{\mathbf{T}}_k \dot{\mathbf{S}} + \Delta \dot{\mathbf{S}}_{nb}, \quad (15)$$

Where $\dot{\mathbf{T}}_k$ - matrix of coefficients of power losses distribution in branches of equivalent circuit of EES which depends on values of complex voltage in its nodes and transformation ratios of coupling transformers; $\dot{\mathbf{S}}$ - column vector of powers in EES nodes; $\Delta \dot{\mathbf{S}}_{nb}$ - column vector of power losses in branches of equivalent circuit from leakage of currents caused by unbalanced transformation ratios of coupling transformers.

Each line of matrix $\dot{\mathbf{T}}_k$ is calculated by the formula:

$$\dot{\mathbf{T}}_{ki} = (\dot{\mathbf{U}}_t \dot{\mathbf{M}}_{\Sigma ki}) \hat{\mathbf{C}}_{ki} \dot{\mathbf{U}}_{dm}^{-1},$$

and each element of vector $\Delta \dot{\mathbf{S}}_{nb}$:

$$\Delta \dot{\mathbf{S}}_{nbi} = (\dot{\mathbf{U}}_t \dot{\mathbf{M}}_{\Sigma ki}) \hat{\mathbf{D}}_{bi} \hat{\mathbf{U}}_b,$$

Where $\dot{\mathbf{U}}_t$ – transposed column vector of voltage in EES nodes; $\dot{\mathbf{M}}_{\Sigma ki}$ – i^{th} row-vector of transposed matrix of branches connections in nodes $\dot{\mathbf{M}}_{\Sigma kt}$, by structure similar to the first matrix of coupling $\mathbf{M}_{\Sigma}$, but instead of values “-1” for nodes of branches end with transformers their transformation ratios are given; $\hat{\mathbf{C}}_{ki}$ – i^{th} row-vector of matrix of currents distribution in nodes $\hat{\mathbf{J}}$ on branches of the grid with the account of conversion coefficient; $\dot{\mathbf{U}}_{dm}$ – diagonal matrix of voltage in nodes without base-load; $\hat{\mathbf{D}}_{bi}$ – i^{th} row-vector of matrix relative conductivity $\mathbf{D}_b$, connecting set node with base; $\hat{\mathbf{U}}_b$ – column vector, each element of which is equal to voltage of base node [12].

The latter component of the expression (15) $\Delta \dot{\mathbf{S}}_{nb}$ implicitly depends on powers of generation and consumption (as a result of values of voltage in nodes) and represents "natural losses" in electrical grids of EES, caused by adjusting influences on supply transformers, necessary for maintenance of technical installations and providing optimum distribution of active and reactive powers fluxes. For obtaining numerical value of noted component of power losses it is necessary to multiply it by the individual line $\mathbf{E}$ of (n-1) dimensionality, where n - quantity of EES nodes:

$$\Delta \dot{\mathbf{S}}_s = \mathbf{E} \cdot \Delta \dot{\mathbf{S}}_{nb}.$$

Another component $\dot{\mathbf{T}}_k \dot{\mathbf{S}}$ for electrical grids of power market which actually have no own loads, determines quantity losses (by branches) from mutual and transit overflows of power.

$$\Delta \dot{\mathbf{S}}_{mt} = \dot{\mathbf{T}}_k \cdot \dot{\mathbf{S}}. \quad (16)$$

According to physical sense of distribution losses matrix $\dot{\mathbf{T}}_k$, its each column $\dot{\mathbf{T}}_k^{(i)}$ is a set of factors which characterize power influence of separate node $\dot{S}_i$ on losses in branches of equivalent

circuit of EES, and on mutual power losses as a whole.

If we assume, that factors of matrix $\dot{\mathbf{T}}_k$ do not change then, at change of power value of i^{th} node by $\delta \dot{S}_i$ power losses in branches of equivalent circuit of EES which are equal will also change

$$\delta \dot{S}_{mt\ i} = \dot{\mathbf{T}}_k^{(i)} \cdot \delta \dot{S}_i. \quad (17)$$

For the case of power correction in i^{th} node, change of power losses in EES will be calculated by the formula

$$\delta \dot{S}_{mt\ i} = t_i \cdot \delta \dot{S}_i, \quad (18)$$

Where t_i – factor of losses sensitivity from mutual and transit overflows in EES to power change in i^{th} node

$$t_i = \frac{\delta \dot{S}_{mt}}{\delta \dot{S}_i} = \frac{\delta P_{mt}}{\delta P_i} + j \frac{\delta Q_{mt}}{\delta P_i} + \frac{\delta Q_{mt}}{\delta Q_i} - j \frac{\delta P_{mt}}{\delta Q_i}, \quad (19)$$

or taking into consideration (17), the factor of sensitivity t_i can be determined, if column vector $\dot{\mathbf{T}}_k^{(i)}$ is multiplied by correspondent individual row vector $\mathbf{E}_1$ with dimensionality m (branches quantity of equivalent circuit of EES):

$$t_i = \mathbf{E}_1 \cdot \dot{\mathbf{T}}_k^{(i)}.$$

Vector $\dot{\mathbf{T}}$ obtained from sensitivity coefficients of power losses t_i to changes in i^{th} node, is the vector of sensitivity which creates connection between gains of power losses in EES branches and changes of power in its nodes. As active power losses are optimization criteria then first of all factor of sensitivity of active power losses to changes of powers components in nodes is of interest for us:

$$\delta P_{ez_P} = \mathbf{T}_P \cdot \delta \mathbf{P}, \quad \delta P_{mt_Q} = -\mathbf{T}_Q \cdot \delta \mathbf{Q}, \quad (20)$$

Where $\delta \mathbf{P}$ and $\delta \mathbf{Q}$ – change of active and reactive powers in system nodes accordingly; $\mathbf{T}_P$, $\mathbf{T}_Q$ – active and reactive components of vector $\mathbf{T}$ accordingly.

Taking into account that $\delta Q_i = \delta P_i \cdot \text{tg} \varphi_i$, it is possible to write down (20) as

$$\delta P_{mt} = \mathbf{T}_{\delta P} \cdot \delta \mathbf{P}, \quad (21)$$

Where $\mathbf{T}_{\delta P} = (\mathbf{T}_P^{TR} - \mathbf{K} \cdot \mathbf{T}_Q^{TR})^{TR}$ – vector of sensitivity of mutual active power losses to change of active-powers of EES nodes (TR – transpositioning operator); $\mathbf{K}$ – diagonal matrix the elements of which is the value $\text{tg} \varphi_i$ for separate nodes of EES.

The basic advantage of (21) and vector of sensitivity $\mathbf{T}_{\delta P}$ is the fact, that power influence of separate node on mutual power losses in EES is determined only by one real coefficient. At the same time, the latter is determined in the assumption, that at change of P_i by magnitude δP_i , the value $\text{tg} \varphi_i$ remains invariable, that cause a certain error in calculations and requires reducing of conversion term of sensitivity vector $\mathbf{T}_{\delta P}$.

Correction of electricity tariffs taking into account sensitivity of losses

Determined above sensitivity coefficients of mutual and transit losses in EES as components of efficiency parameter of WEM (14), are possible to use in the problem of technically-proved correction of electricity tariffs for achievement of maximum effect.

Value of tariff for separate PP taking into account measure of its influence on mutual and transit power losses in EES can be calculated by the formula

$$u_{ES_i} = u_{EGC_a} - k_p \cdot T_{\delta P_i},$$

Where u_{EGC_a} – average tariff for given power generating company; k_p – cost coefficient which determines the set measure of influence of power losses factor in electrical grids of WEM on magnitude of tariff; $T_{\delta P_i}$ – element of sensitivity vector of power losses in EES, which corresponds to i^{th} PP.

For correction of tariff for supply of electric energy by the set power generating company as a whole it is possible to take advantage of averaging method

$$u_{EGC_i} = u_{EGC_a} - k_p \cdot \frac{\sum_{j \in M_i} T_{\delta P_j} \cdot P_j}{\Delta P_{mt}}, \quad (22)$$

Where ΔP_{mt} – total mutual losses in EES for given step of forecasted schedule of its loads determined according to (16).

Advantage of such approach is that during correction of electricity tariffs, approached to real values of mutual and transit power losses which change according to the change of EES structure scheme and its parameters are used. Taking into account, that noted component in tariff creation is important enough; adjusting of its influence will allow to take more technically proved decisions during formation of procurement price at electric power for separate EGC.

Using (21), (22) it is possible to prove technically the raise of tariffs for supplied energy for separate stations which functioning provides decrease of own and transit losses in EES. PP of small power belong to them. They are located directly near electric power consumers and reduce load on buses of system substations by power generation, decreasing power loss and electric power in electrical grids of WEM. Small HPP, Wind stations, cogeneration installations, etc can be examples of such stations.

Similar approach can be applied to solution of the problem of effective and substantiated formation of electricity tariffs for power market consumers. It is necessary to consider, that tariffs for the given consumer should fluctuate in the limits from u_{CON_min} to u_{CON_max} . It is necessary to consider two conditions:

- The maximum tariff for consumers u_{CON_max} should be chosen to provide the minimum standard efficiency of consumer activity;
- In average tariff u_{CON_a} redundant losses in power market electrical grids, caused by maintenance inefficiency system creating (distributive - for regional power companies) electrical grids should not be included.

Taking into account the above-mentioned, the electricity tariff for given consumer, taking into consideration its influence on power losses in EES can be calculated:

$$u_{CON_i} = u_{CON_a} + k_p \cdot T_{\delta P_i}. \quad (23)$$

Using (23), decrease of purchasing tariff, as a result of feature of their functioning can be technically proved for some consumers. So, if consumer pays enough attention to problems of consumption schedule optimization, its load leveling, etc its function in system can lead to decrease of total losses in EES ($T_{\delta P_i} < 0$) at certain steps of load diagram of EES, and, accordingly, to electricity tariff decrease.

Conclusions

1. Optimization of load distribution of EES between power plants and their units is important optimization part of normal modes of electric energy system operation. Statement of optimization problem has changed with transition to new market relations and there was a necessity for new optimization criteria. During formation of optimization criteria of EES function, both economic and technical aspects of its maintenance, one of which is the magnitude of mutual and transit losses of electric power in its electrical grids should be taken into consideration.

2. The problem of efficiency increase of WEM performance contains two subtasks: formation of

validated electricity rates and providing of optimum operation modes of EES which are interconnected and should be solved in complex. Only under such conditions, using economic levers which are formed taking into account engineering constraints, there is a possibility to provide equal competitive conditions for operation of separate subjects of power market and to stimulate them to implementation of measures directed on optimization of WEM function.

3. At determination of optimum distribution of resistive load between power plants in EES it is possible and reasonable to use the approach built on application of optimality conditions, resulted in [8]. Separate PP are represented in equivalent circuit of EES by active resistances method of definition of which depends on statement of solved problem optimization. Optimum PP loads are determined, taking into consideration results of account of steady mode of EES by r-equivalent circuit.

4. In the process of electricity rates formation in WEM it is necessary to consider a measure of separate subjects influence on modes of EES operation, and also mutual and transit losses of electric power in its electrical grids. Using considering technique of electricity rates correction which is based on results of sensitivity analysis of mutual power losses in EES, it is possible to provide transition to multisisonal (hourly) tariffs which will take into account function peculiarities of separate energy generating companies, power plants and electric power consumers.

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