Innovative technologies.

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THE PHASED OPTIMIZATION CONCEPT OF MODELS FOR ASSESSING AND FORECASTING THE STRUCTURE AND MODES OF USE OF ENERGY COMPLEXES

The phased optimization concept of models for assessing and forecasting the optimality of the structure and modes of using energy complexes is proposed.

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In [1–6], the phased optimization concept of models for assessing and forecasting the optimality of the structure and modes of using energy complexes was proposed.

The comparative analysis of the matrices of the weighted average prime cost of electricity produced during the operation of the components of the power system in modes other than the base load mode, can be used as justification for choosing the best solution to this problem.

The weighted average prime cost of electricity produced during the operation by each component of the power system depends on: the amount of capital investment, including the cost of any loan needed to finance the construction, and may be one of the main components of the final cost of electricity; lifetime cost of operation; fuel costs.

Usually, elements of the matrix of the weighted average prime cost ($\boldsymbol{c_{jf\tau}}$) for the technology $\boldsymbol{j}$ in $\boldsymbol{f}$ mode is determined by one of versions of the fairly common formula. The formula specific version depends on technological, regional and economic parameters. Taking into account the stochasticity and quasi-dynamism of its parameters formula takes the following form:

$$(\boldsymbol{c_{jf\tau}}) = \frac{\sum_{\tau}^{T_j} \frac{\left\{C_{\tau}^{cap} + C_{\tau}^{const(f)} + C_{\tau}^{var(f)}\right\}}{(1+i)^{\tau}}}{\sum_{\tau}^{T_j} \frac{e_{jf\tau}}{(1+i)^{\tau}}}, \quad (1)$$

where: $\boldsymbol{e_{jf\tau}}$ – annual energy amount; $\boldsymbol{c_{\tau}^{cap}}$ – capital investment; $\boldsymbol{c_{\tau}^{const(f)}}$ – constant operating expenses; $\boldsymbol{c_{\tau}^{var(f)}}$ – variable operating costs, which according to manufacturers include the cost of fuel; $\boldsymbol{T_j}$ – the $\boldsymbol{j}$-technology life cycle; $\boldsymbol{\tau}$ – current year.

The dependence of the most parameters, such as $\boldsymbol{e_{jf\tau}}$, $\boldsymbol{c_{\tau}^{const(f)}}$, $\boldsymbol{c_{\tau}^{var(f)}}$, included in (1) on the mode $\boldsymbol{f}$ is explained by the use of technologies, that are part of the energy complex, in modes $\boldsymbol{f}$ other than the base load mode.

To calculate the sequence of permissible volumes of generation and energy consumption of each technology $\boldsymbol{j}$ of the energy complex $\boldsymbol{k}$ at each step $\boldsymbol{\tau}$ of its life cycle $\boldsymbol{\Phi_{\tau k}\{L_k(LACE_k - LCOE_k), F[PPF(\tau), ET(k,\tau), FCF(k,\tau), EGR(\tau)]\}}$, the model of economic and technological influence is used. This model is the development of the logistic model of the external influence of Bass, due to the introduction the functional of economic and technological influence [2] $\boldsymbol{F[PPF(\tau), ET(k,\tau), FCF(k,\tau), EGR(\tau)]}$ into the Bass model. Where $\boldsymbol{PPF}$ – regional purchasing power factor, $\boldsymbol{ET}$ – efficiency of technology, $\boldsymbol{FCF}$ – final cost factor, $\boldsymbol{EGR}$ – economy growth rate.

Then, calculated the development scenario of the vector

$$\boldsymbol{E_{S\tau}^{k}\{\Phi_{\tau k}\{L_k(LACE_k - LCOE_k), F[PPF(\tau), ET(k,\tau), FCF(k,\tau), EGR(\tau)]\}\}}, \quad (2)$$

such, that minimizes $\boldsymbol{\mu^k}$ – the total inconsistency measure of the vectors of supplied and consumed energy for energy complex $\boldsymbol{k}$.

The objective function of minimizing the total inconsistency of supplied and consumed energy vectors during the forecast period with the observance of mandatory limits is as follows:

$$\boldsymbol{\mu^k = \sum_{\tau=1}^{T}\left(E_{S\tau}^{k} - E_{C\tau}^{k}\right) \forall\, u(\tau,k), \xi(\tau,k) \rightarrow min};$$

where: $\boldsymbol{E_{S\tau}^{k}}$, $\boldsymbol{E_{C\tau}^{k}}$ – total volumes of supplied and consumed energy; $\boldsymbol{u(\tau,k)}$ – vector of control actions for energy complex $\boldsymbol{k}$ at the time $\boldsymbol{\tau}$; $\boldsymbol{\xi(\tau,k)}$ – vector of random external actions for $\boldsymbol{k}$ at the time $\boldsymbol{\tau}$.

The optimal target trajectory of the development vector (2) for all $\boldsymbol{\tau} = \mathbf{1}, \mathbf{2}, \dots, \boldsymbol{T}$, is determined on the basis of data, obtained from external sources and those, that are the initial data for calculations at the current time $\boldsymbol{\tau}$: the required balance of total power $\boldsymbol{P_{\tau}^{k}}$; installed capacity utilization rate $\boldsymbol{ICU_{jf\tau}}$; volumes of constant operating expenses; amounts of variable operating costs.

The obtained results allowed us to calculate a set of the following matrices, which are necessary to forecast the optimal modes $\boldsymbol{f_{j\tau}}$ of use of the technological complex at each stage of time $\boldsymbol{\tau}$: $(\boldsymbol{c_{jf\tau}})$ **–** prime cost of technology $\boldsymbol{j}$, in mode $\boldsymbol{f}$, used during simulation for several set values of discount $\boldsymbol{i}$; $(\boldsymbol{t_{jf\tau}})$ – technological parameters; $\{\boldsymbol{e_{jf\tau}}(\boldsymbol{P_{j\tau}^{MAX}}, \boldsymbol{YH})\}$ – accessible annual generation volumes; $\{\boldsymbol{p_{jf\tau}}(\boldsymbol{P_{j\tau}^{MAX}}, \boldsymbol{ICU_{jf\tau}})\}$ – accessible loads; $\{\boldsymbol{c_{jf\tau}^{ti}}(\boldsymbol{P_{j\tau}^{MAX}}, \boldsymbol{ICU_{jf\tau}})\}$ – cost of electricity supply for ***ti*** interval; $(\boldsymbol{b_{jf\tau}^{ti}})$ – binary matrix of optimal sets of modes of generating and accumulation technologies, in terms of minimizing the total cost of electricity supplied during ***ti*** interval at this stage $\boldsymbol{\tau}$.

The binary matrix elements $\boldsymbol{b_{jf\tau}^{ti}}$, which provides the optimal set of modes of generation and accumulation in terms of minimizing the total cost of energy on the ***ti*** interval, were defined as the solution to the optimization problem (3):

$$\sum\nolimits_{j\tau} \boldsymbol{c_{jf\tau}^{ti}} * \boldsymbol{b_{jf\tau}^{ti}} \Rightarrow \boldsymbol{min}\,, \tag{3}$$

if performing restrictions of technological admissibility.

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