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MODERN SOLUTIONS TO MODELING AND OPTIMIZATION OF THE STEADY STATE OF MULTI-ENERGY SYSTEMS

Integrated management of the energy regime of the energy system implies considering it as a multi-energy system - that is, taking into account the production, transmission, distribution and consumption of various energy resources in their relationship. Management of the development (planning and design) and functioning (operation) of energy systems of this type implies the mandatory coordination of their single-resource subsystems. The calculation of the distribution of energy flows in a multi-energy system is of independent importance - to determine the existence and acceptability of operating modes, and as an essential component of solving the problems of optimization of regimes - usually in order to ensure the minimum cost of production, transmission and distribution of energy resources. In the problems of optimizing the modes, the location (when managing development) and the load (when controlling the operation) of energy sources and network elements are determined.

The calculation of the flow distribution is based on a mathematical model of the steady state system. For any one-resource system, such a model in its most general form includes topological equations (corresponding to Kirchhoff's laws) and component equations - which determine the interconnection of the parameters of the regime along the arcs of the graph of the system diagram. When two or more types of energy resources are taken into account, the equations of conjugation of single-resource systems — the equations of energy hubs — are also included in the model. To date, a large number of models of power hubs for various purposes and detailing have been developed and are being intensively developed - from fixed nodal injection of resources in coupled systems to modeling the hub as an integrated system in which the conversion performance in a complex way depends on the volume of the converted resource.

The mathematical model of flow distribution is usually non-linear. Among the calculation methods, the most universal is the Newton-Raphson method. At the same time, for specific productions, other (as a rule, non-universal) methods can be used, which in their limited areas of applicability show, however, greater efficiency (convergence to solution, speed) than the classical Newton-Raphson method.

In optimization problems, the equations of the flow distribution model act as constraints-equalities on the parameters of the regime. You can track the continuity of the statements and methods for solving the problems of optimizing the regime of a multi-energy system with the well-known problems of determining the optimal load of power plants (differing in efficiency and location), as well as the optimal transformation ratios in the electric power system. The main difference between optimizing a multi-energy system from these examples is determining the optimal combination of the types of energy used (therefore, the parameters of energy hubs are necessarily included in the number of optimized parameters).

Based on an analysis of publications describing the results of research in the field under consideration, an attempt is made to systematize mathematical models and methods for calculating the flow distribution, statements and methods for solving optimization problems that are currently used to study steady-state modes of multi-energy systems.

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