INFORMATION FLOW PROCESSING WHEN MONITOR AND CONTROL SMART GRID REGIMES

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The paper proposes an approach to processing information flows under the monitoring and control of smart grid regimes, based on the creation of a new information technology infrastructure (IT infrastructure) under the automated control of intelligent energy systems, designed to process the information flows and improve their quality. A two level information technology is offered to support decision making in controlling smart grid regimes. This technology integrates intelligent tools for situation analysis and software systems for modeling and regime control. The use of IT infrastructure allows to create a single information space, including data and knowledge as well as a set of mathematical models and methods for solving electrical power engineering problems under the active adaptive management.

Keywords: intelligent power system; IT infrastructure; information stream; mode control; models; information quality.

ОБРАБОТКА ИНФОРМАЦИОННЫХ ПОТОКОВ ПРИ МОНИТОРИНГЕ И УПРАВЛЕНИИ РЕЖИМАМИ УМНОЙ СЕТИ

В статье предлагается подход к обработке информационных потоков при мониторинге и управлении режимами умной сети, основанный на создании новой информационной технологической инфраструктуры (IT-инфраструктуры) под автоматизированным контролем интеллектуальных энергетических систем, предназначенной для обработки информационных потоков и улучшения их качества. Предлагается двухуровневая информационная технология для поддержки принятия решений в управлении режимами умной сети. Эта технология интегрирует интеллектуальные инструменты для анализа ситуации и программные системы для моделирования и контроля режима. Использование IT-инфраструктуры

позволяет создать единое информационное пространство, включающее данные и знания, а также набор математических моделей и методов для решения проблем электроэнергетики под активным адаптивным управлением.
Ключевые слова: интеллектуальная энергетическая система; IT-инфраструктура; информационный поток; контроль режима; модели; качество информации.

Currently, there is an active development of a direction in the world called Smart Grid (intelligent energy systems or intelligent electrical networks) - electrical energy systems using new technologies in both power equipment and information technology, aimed at improving technical and economic performance. The focus of specialists is primarily on improving the technological infrastructure of the energy sector, without which the implementation of modern information technologies is impossible. At the same time, the development of a methodology and new information and telecommunication technologies is necessary, which should become the basis for smart [8] energy systems. The paper proposes an approach to processing information flows in the monitoring and management of modes of intelligent energy systems, which involves the integration of information and mathematical technologies and the use of international data standards.

The challenges of creating a Smart Grid. Smart Grid includes all the main traditional components of power systems: generation, transmission and conversion of electrical energy, as well as consumers, but with a qualitatively new technological level and characterized by close interconnection. Smart Grid should provide an increase in the reliability and cost-effectiveness of electricity production based on the use of modern high-intelligence means of control and management, integration of renewable energy sources, as well as distributed generation and energy storage, large-scale monitoring of modes and their management using new tools and technologies [1].

The common problems of creating intelligent energy systems (IES) from the perspective of information and communication technologies are as follows: 1) the need to develop information and communication technologies that allow for the creation of qualitatively new monitoring and control systems for energy systems; 2) a limited range of offerings in this segment from IT vendors: solutions from foreign developers are quite expensive, there are not enough high-quality domestic developments, or they simply do not exist. In addition, reliance on foreign developers is not welcomed, as dependence on foreign firms is one of the threats to the cybersecurity of IES [2].

At the current stage of electrification system intelligence, the most important issues are the development of information technology infrastructure (IT infrastructure) in the automated control systems (ACS), ensuring the construction of a multi-level management system that takes into account the reliability, economy, and efficiency of power system operation. In addition, the implementation of new systems for collecting, transmitting, and processing streams of information will require the development of technologies and methods for modeling the processes and events under study when managing the power system. Therefore, the following tasks become relevant: 1) collection, transmission, and processing of data streams; 2) development of new generation software complexes (distributed, exchanging information or using common information resources); 3) development of intelligent decision support components for power system operation [3].

IT infrastructure for power systems. To create and develop power systems, based on the experience of the Institute of Energy Systems named after Chernyshevsky of the Siberian Branch of the Russian Academy of Sciences [4-5], it is proposed to identify the following main components in the IT infrastructure: intelligent infrastructure; information infrastructure; computing infrastructure; telecommunications infrastructure. The telecommunications infrastructure is built on generally accepted principles (for example, similar to the telecommunications infrastructure of the data transmission network of the Siberian Branch of the Russian Academy of Sciences), taking into account the requirements of computer and information security. The intelligent infrastructure includes intelligent components (for example, the aforementioned intelligent decision support components for power system operation). The information infrastructure includes technologies and tools for describing, storing and processing data. The core of the information infrastructure is the Repository, which stores metadata (descriptions of data flows, databases, data models, etc.). The computing infrastructure integrates software complexes (for example, for modeling [14] and managing power system operation). Automated energy management systems can also be classified under this infrastructure.

"The elements of the IT infrastructure of dispatch control include:

Information collection and transmission system (ICTS);

Dispatch and technological management communication network;

Supervisory Control and Data Acquisition System (SCADA)[7];

Common Information Model (CIM);

Information display system;

Energy Management System (EMS);

Market Management System (MMS);

Transmission and Distribution Management System (DMS)."

The proposed approach to processing information flows for monitoring and managing modes of power systems IES.

The term "information flow" refers to the set of measured process variables over a certain period of time [6]. When monitoring and automating the modes of the power system, analysis and processing of information flows are essential.

The CEP (Complex Event Processing) model [9] is proposed to be used for real-time processing of a set of events from various sources (event streams) with the aim of detecting significant events based on one or several event streams, or identifying a series of events over a certain period of time. The CIM (Common Information Model) model, based on the ODM and CIM data formats, allows building models of any complexity, which can then be converted into any well-known energy data format or into any new data format using additionally connected modules. ODM (Open Model for Exchanging Power System Simulation Data) is an open model for exchanging data in power system modeling [14]. ODM is an international open data exchange standard for modeling and calculating energy systems, supporting dynamic calculations [10-11].

From the above, it is evident that there is a need for real-time processing of large volumes of information of varying quality and the formation of such information flows that would ensure the required accuracy of solving operational tasks. The scheme of processing information flows during monitoring and control of modes in IES (Integrated Energy System) is presented in Fig. 1.

Two-level technology for decision support in managing operating modes in Integrated Energy Systems.

The proposed two-level information technology, shown in Fig. 2, in which:

- on the first (upper) level, using intelligent technologies, a qualitative analysis of situations arising in the IES (Integrated Energy System) will be performed;
- on the second level, using adapted software complexes, numerical calculations are carried out for situations determined with consideration of the qualitative analysis results.

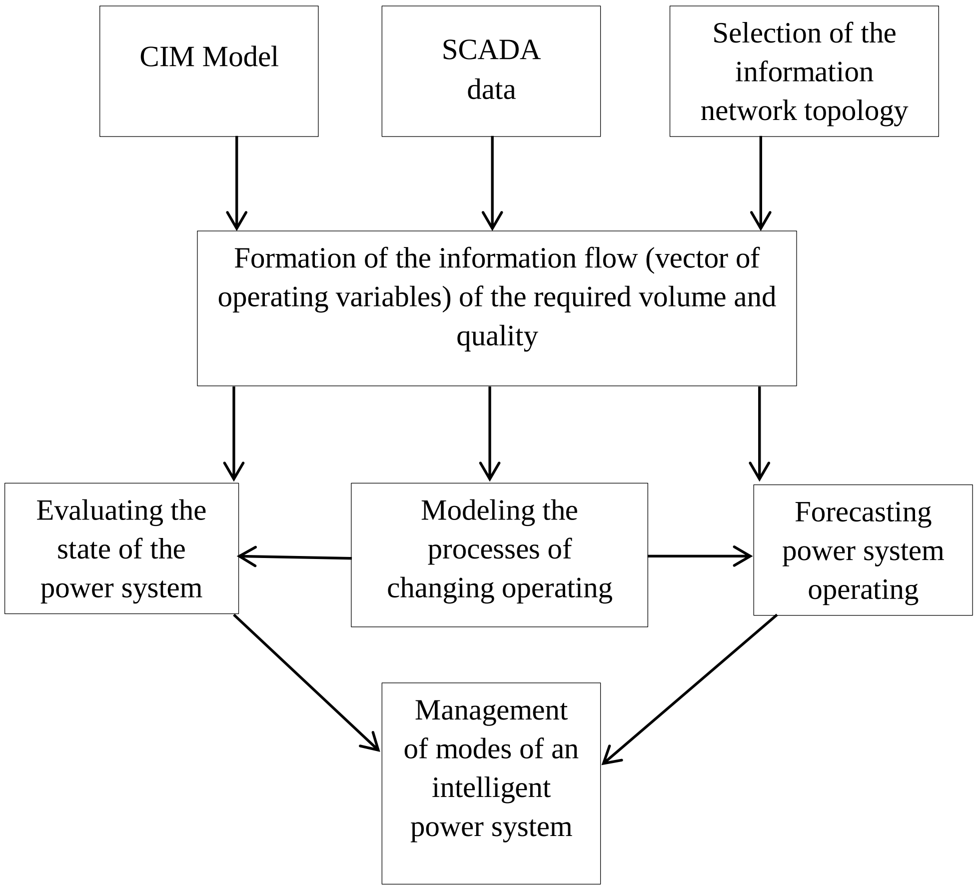


Fig. 1.

General scheme of information processing flows in monitoring and management of modes of the intelligent power system.

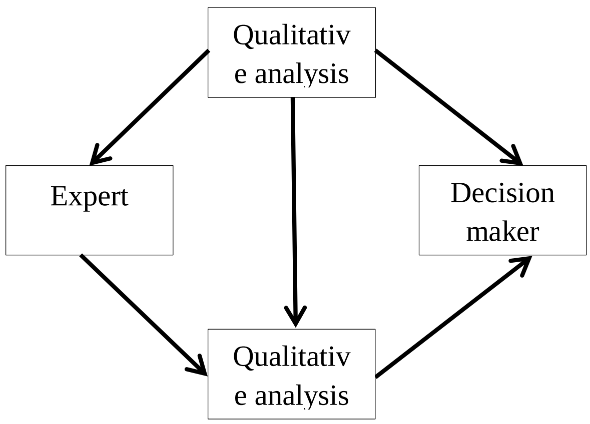


Fig. 2. Two-level decision support information technology for managing modes in the Integrated Energy System (IES)

As intellectual decision-making support technologies at the qualitative analysis stage, it is proposed to primarily use ontological, cognitive, and event modeling technologies (these technologies have been tested in the Energy Systems Institute of the Russian Academy of Sciences for energy security research, scientific prototypes of instrumental tools are available, integrated within the intellectual IT environment) [12-13]. In the future, intelligent technologies can be supplemented with artificial neural network technologies, fuzzy sets, genetic algorithms, and wavelet analysis, depending on the properties of information flows [14].

Classification of information and mathematical models for its description.

Information on the parameters of the mode is divided in [6] into 4 groups: deterministic, probabilistic, fuzzy, and interval-based – for the possible application of various mathematical models under the conditions of active-adaptive control of the power system (Fig. 3). Deterministic information is based on regular cause-and-effect relationships and is conditioned by numerically unambiguous assignments of equipment types, their composition, and nominal parameters. Probabilistic information describes the stochastic nature of mode parameter changes, as well as the set of network elements corresponding to a given mode. Fuzzy information – the values of mode parameters are described by membership functions of a fuzzy subset of their variation. Interval information is typical for cases when only an approximate range of mode parameter changes is known, formed by their minimum and maximum possible values.

As an example, the technology for improving the quality of information flows based on fuzzy set theory is considered (Fig. 4).

The quality of measurement information is determined using a quality criterion [4]. To do this, the entire information base is represented in the form of four sets:"

A_I– the set of reliable values;
A_{II}– the set corresponding to the full volume of information;
A_{III} – the set corresponding to an incomplete volume of information;
A_{IV} – the set of unreliable values.

To determine the completeness and reliability of information, ensuring the required accuracy of mode management tasks, a threshold level α is introduced for fuzzy regions, the quantitative value of which corresponds to the optimal parameters of information quality:

$$\alpha = \frac{1}{lnN * \sum_{i=1}^{N} \mu_{A_i} \sim (A_i)} [\sum_{i=1}^{N} \mu_{A_i} \sim (A_i) ln \sum_{i=1}^{N} \mu_{A_i} \sim (A_i) - \sum_{i=1}^{N} \mu_{A_i} \sim (A_i)],$$

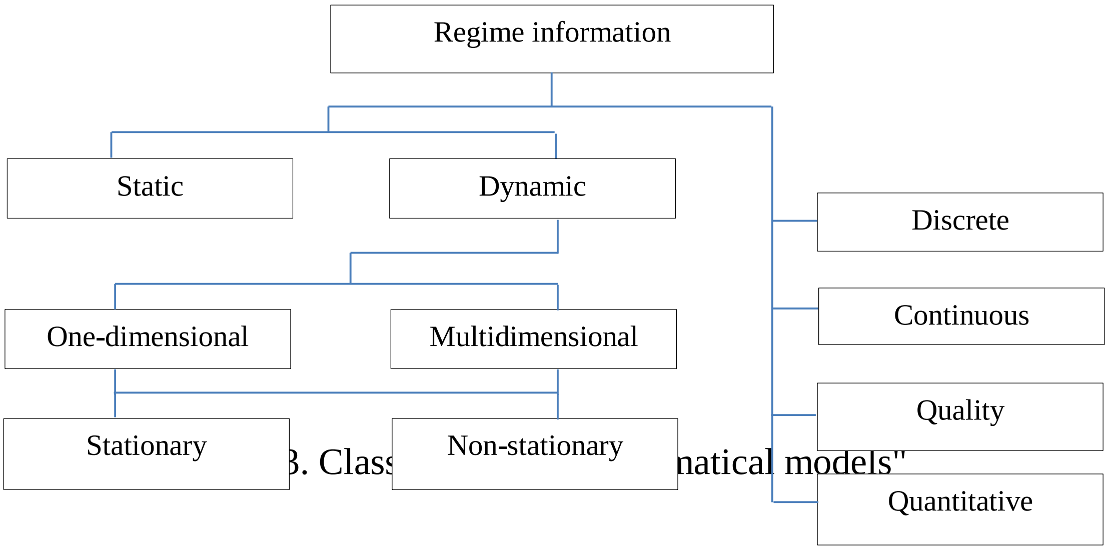
(1)

where $\mu_{A_i} \sim (A_i)$ - membership function for the i-th of the above sets.

The set of α-level is described as $\tilde{A}_\alpha = \{\frac{\tilde{A}_i}{\tilde{A}_i} \in A, \mu_{A_i} \sim (A_i) \geq \alpha$ where

$$A_i \in A, \forall \alpha \in [0,1].$$

The proposed quality criterion allows classifying information and applying those mathematical models that provide the highest accuracy in its description.



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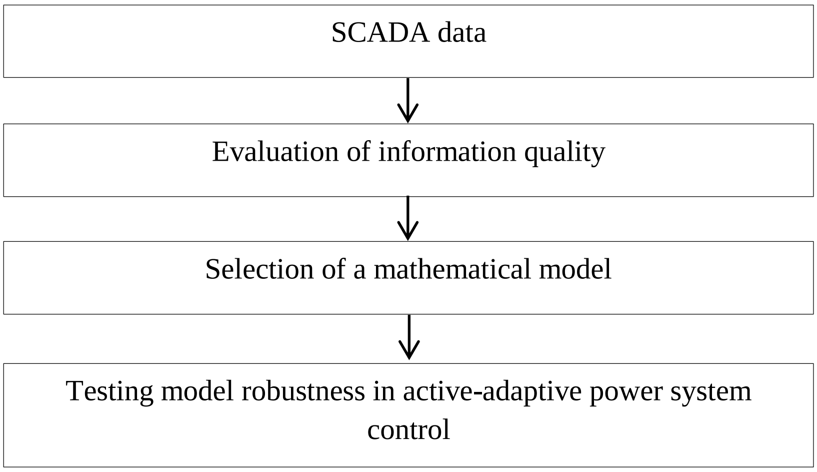

Fig. 4. Technology for improving the quality of information flows

Conclusion. In this work, an approach to the development of a new IT infrastructure for Intelligent Energy Systems (IES) is proposed, which includes a unified information space and, thus, creates prerequisites for constructing a multi-level management system for intelligent power systems. It is proposed to expand the class of models used in solving power engineering problems by including CEP and CIM models.

The proposed two-level information technology for decision-making support in IES mode management is considered, integrating intelligent technologies and software packages for modeling and mode management. A new scheme for processing information flows of varying degrees of completeness and reliability in the management of power systems modes is presented. A classification of information types about mode parameters is provided, and the feasibility of using different mathematical models depending on the quality of mode information is demonstrated.

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