Analysis of energy security threats based on semantic and linear optimization models of the fuel and energy complex development

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Abstract. The article proposes the use of semantic models and linear optimization models for the analysis of energy security threats and justification of emergency situations in the event of threats, as well as the integration of mathematical and semantic (on the example of cognitive) modeling for the study of energy security problems. Also to study the energy security problems a two-level technology is proposed that integrates the stages of qualitative analysis (using semantic modeling tools) and quantitative analysis (using linear economic and mathematical models and traditional software systems).

Introduction

The main content of the tasks for studying the problem of energy security is to predict the conditions for the functioning and development of energy systems and the fuel and energy complex as a whole, taking into account possible critical and emergency situations (CS and ES), to assess the state in these conditions and identify " bottlenecks" in the systems of fuel and energy supply to consumers, in the choice of possible alternatives and specific measures to prevent emergency situations and emergencies in these systems or reduce their negative impact [1].

In modern conditions, it became necessary to improve the existing and develop new methodological, model and software tools for conducting such studies, since studies related to the concept of the risk of critical and emergency situations and their consequences begin to occupy a special place. Of particular importance is the task of analyzing possible threats and the formation on this basis of disturbance scenarios (critical and emergency situations) and the related problems of their modeling.

The article proposes the use of semantic models and linear optimization models for the analysis of energy security threats and justification of emergency situations in the event of threats, as well as the integration of mathematical and semantic (on the example of cognitive) modeling for the study of ES problems.

This work is an integral part of the energy security research conducted at the Energy Security Department of the Melentiev Energy Systems Institute Siberian Branch of the Russian Academy of Sciences [1]. Similar studies, developments and models for such studies are mainly focused on solving the problems of long-term planning of the energy industry work under normal operating conditions with a horizon of up to 15-20 years. Similar works carried out in other teams are a local or regional nature with the study of the certain problem aspects [2-5]. Comprehensive studies that allow assessing the possibilities of all energy industries interconnected work and determining the consequences for consumers of energy resources in the event of emergency situations in the operation of one industry or several industries at the same time have not been carried out before.

1. Study scheme

To study the energy security problems, a two-level technology is proposed that integrates the stages of qualitative analysis (using semantic modeling tools) and quantitative analysis (using linear economic and mathematical models and traditional software systems) (Fig. 1) .

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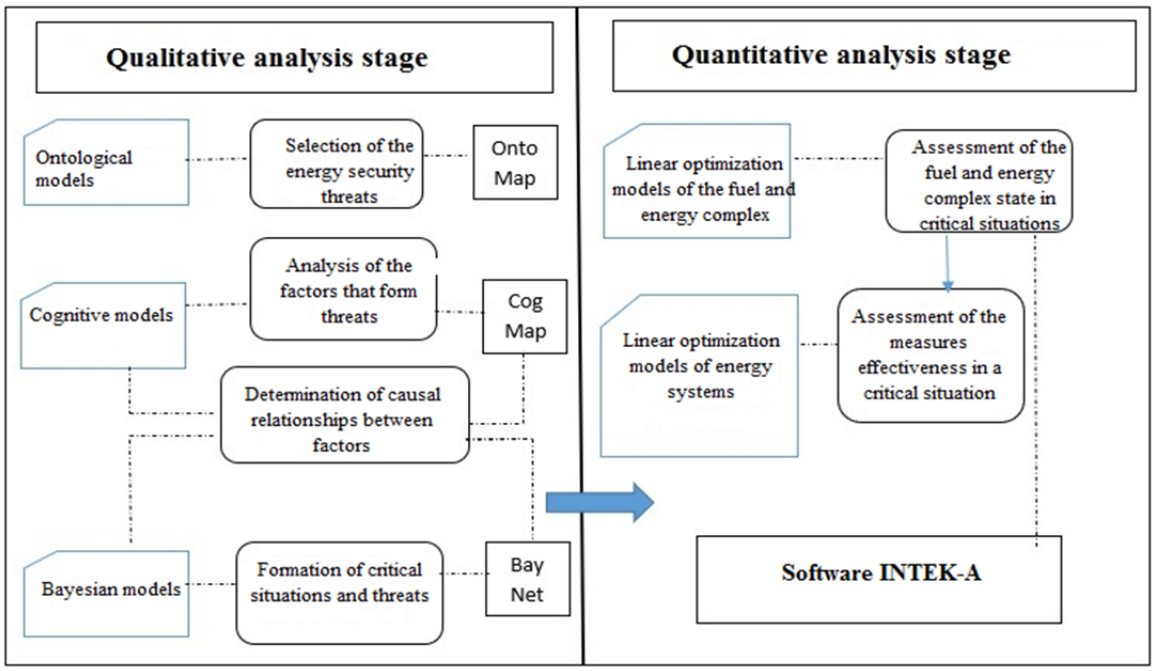

Fig 1. Tasks to be solved and modeling methods used in studies of assessing the impact of threats on the state of energy security

In modern conditions, the problem of studying threats to energy security and the factors that form these threats acquires the greatest importance. In this case, it is possible to justify the occurrence of certain critical or emergency situations.

2. Main threats to energy security

Based on the analysis of the energy sector state and the conditions for its development, the main strategic threats to energy security were identified [1]:

- insufficient level of investment in the fuel and energy sector;
- insufficient growth of explored hydrocarbon reserves;
- reduced opportunities to increase gas production;
- high depreciation and low rates of equipment renewal in the fuel and energy sector.

The analysis of these threats and the formation of CS and ES on their basis takes place at the level of qualitative analysis. At this level, it is possible to use semantic modeling methods (Fig. 1), which can be considered as methods for analyzing and substantiating threats to energy security, the formation of CS and emergency situations, and as methods for situational analysis and management.

3. Scheme of models

At the stage of qualitative analysis, using cognitive modeling methods, models of worsening/improving situations with investments and one of the important strategic threats "Reduced opportunities to increase gas production" were built (Fig. 2).

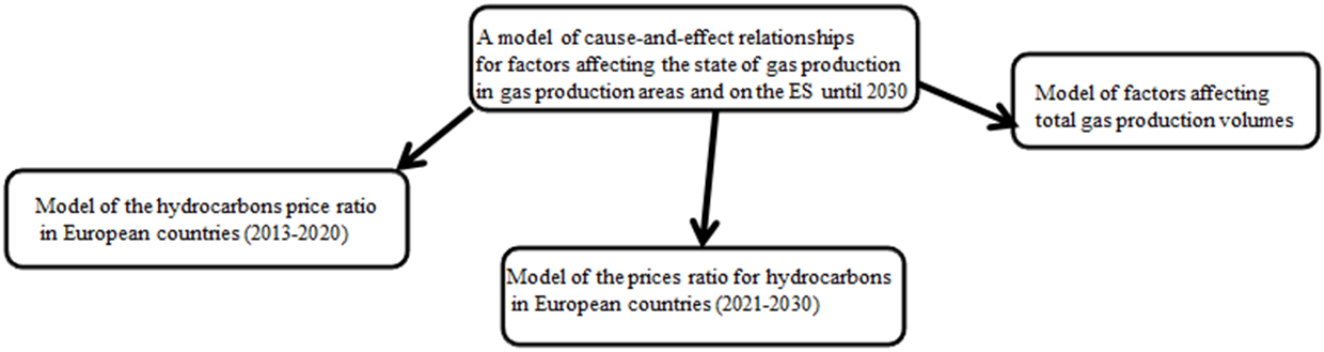

Fig. 2. The system of deterioration/improvement models for the strategic threat situation on the energy security "Reducing the opportunities to increase gas production"

Using the methods of semantic, namely cognitive, modeling for the analysis of energy security threats, it is possible to reasonably form various emergency situations and evaluate them at the stage of qualitative analysis.

At the stage of quantitative analysis, using a scenario approach, based on the knowledge of experts and of the studied threats cognitive models, critical situations are formed that arise among consumers of energy resources and in the energy industries.

Using linear optimization models of energy systems and fuel and energy complex [6], the tasks of the energy system state assessing in the conditions of threats realization to energy security in the form of critical situations are solved to determine:

- rational use of energy facilities production capacities;
- distribution of energy resources certain types by categories of consumers;
- rational use of interregional transport links capacity;
- the size of deficits in energy resources certain types for the considered categories of consumers across the country.

Conclusion

This paper proposes the use of mathematical and semantic modeling for conducting research on the analysis of threats to energy security. A two-stage scheme for conducting research and an algorithm for experimental calculations are proposed. Examples of the cognitive threat models application with the construction of cause-and-effect relationships are given.

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