Regarding Informational Model Of Energy Management Systems

A Lyakhomskii¹, A Petrochenkov², EPerfilieva³ and A Kutepov⁴

¹ Head Chair, National University of Science and Technology MISIS, Moscow, Russia
² Head Chair, Perm National Research Polytechnic University, Perm, Russia
³ Associate professor, National University of Science and Technology MISIS, Moscow, Russia
⁴ Associate professor, National University of Science and Technology MISIS, Moscow, Russia

E-mail: pab@msa.pstu.ru

Abstract. The relevance of the management of energy resources of industrial enterprises on the basis of the provisions and requirements of energy management systems with the integration of technical and management components of the energy consumption process with the unification of personnel on the basis of a single organizational and technological platform is considered. The characteristic of energy management systems consulting is given, the expediency of its implementation by specialized organizations is substantiated.

To design the information model of Energy management system it’s necessary to identify and analyse the department structure, the whole list of the documents of the department and analysis of the routes of the department documents according to the research data.

1. Introduction

Energy management systems (EMS) [1] are the complex of interrelated and interacting elements of industrial enterprises for the management of energy resources in order to increase the efficiency of their use, taking into account not only technical [2-4], but also organizational [1, 5], motivational [1, 5, 6], innovational [7], informational [8–11], marketing [5, 8, 9, 12] and investment [1, 9, 12] aspects.

The relevance of the implementation of EMS is included in the requirements of a number of legislative acts and normative and technical documents and materials [1–3, 9, 10].

Data model, being the basic part of the offering system, must take into account the whole amount of the really existing objects of the automation (documents, departments, executives, elements of the schemes of power supply, etc.) and their relations. The selected model will specify the functionality and the interface of designed system [11, 13, 14].

One of the main features of the designed model must be its high flexibility and adjusting of the system to the specific conditions of activity. A great amount of types of documents were identified at the stage of analysis. Moreover, it can be possible to identify the other types of documents or some changes of the old documents structure further. It means that it’s impossible to plan ahead the tables with the particular set of boxes for either each type of documents or each type of equipment. It’s necessary to have an opportunity to enter new types of equipment or new types of document and edit
the sets or characteristics of boxes exactly during the system usage. It’s absolutely evident that the interface must support such setup.

2. Conceptual provisions and requirements for EMS

Conceptual provisions and requirements, on the basis of which the EMS are developed and operated, comply with the International Standard ISO 50001-2018 “Energy Management Systems. Requirements and guidance for use” [1].

The functionality of hard- and soft-ware in automated and real time mode allows [13]:
- to import from information system, systematize, transform and distribute energy technology information among the participants in the energy consumption process [15];
- to carry out an analytical description of the influence of technological factors on the process of energy consumption with modeling of energy technology profiles;
- to form and issue to the personnel daily tasks on the energy efficiency indicator - specific energy consumption, as well as to carry out the personnel report on the fulfillment of these tasks for each significant energy-consuming object;
- to generate tables with the results of the energy technological efficiency of the work performed with the output on the PC displays of the participants in the energy consumption process;

However, the information is not enough for the chosen company department because we need to take into account the specific of its workflow structure. E.g., on Fig.1 the organizational structure of the Chief power engineering department of the Oil Producing Company is considered [13, 16].

![Figure 1. Organizational structure of Chief power engineering department.](image-url)
It is necessary to analyze the structure of the department workflow. To do this we need to identify the list of documents, structure them and identify their routes.

According to these tasks, the presented section is divided into the next stages:
- Identification and analysis of the whole list of the documents of the department;
- Identification of the department structure;
- Identification and analysis of the routes of the department documents according to the research data of the two previous sections;
- Analysis of the document structure.

Let’s consider the key documents according to “energy departments” at the enterprises.

1) Documents deal with the personnel (such as “The program of personnel training”).

E.g., the detailed structure of the typical sector of Electrical department is considered on Fig.2.

![Figure 2. Organizational structure of the sector of Electrical department.](image)

The program of personnel training is received by all, and for specialists of various qualifications the programs will be different.

For brigades, the training program is developed by the sector chief and affirmed by the department chief. The general part of the program concerns all members of the brigade, but depending on the qualification, each member of the team will have its own specificity.

For masters the program is developed by the department chief deputy and affirmed by the chief engineer.

For the chief deputy and department chief the program is developed by the chief engineer and affirmed by the chief power engineer. In fact, this document is being prepared with the participation of the department chief and his deputy.

2) Documents deal with equipment (such as “Acts about major repairs of the main equipment”).

In the production of repair work, a report is prepared on the work done.

Acts on major repairs of equipment contain a reportable part on the technical requirements and parameters determined in the manufacture of repair work.

One copy of the certificate is sent to the archive of the repair department, and the other copy is kept for further use (maintenance of the technical equipment history) on the sectors - in the archives of the sector chiefs.

The act is created by the sector chief, then signed by the department chief, and then affirmed by the repair department chief “1-6” (Fig.1). Data on labor costs are sent to the planning and economic department (Fig.3).
According to this the main idea of the system function is that there are different ways of navigation within the model and their aim is searching of the particular document. For example, the navigation within the single-line scheme of power supply, installation and its equipment, the hierarchy of documents or the hierarchy of the departments. As a result, the user gets an access to the particular document to provide some activities with it such as the document editing or changes of its status (agreement, making some notes, etc.) all the possible changes of the status are described in the table “Regulated stages of document agreement”.

Moreover, there is an opportunity to create one document from another as a protocol can be created, based on an order. The characteristics for each document can be set. The result of this stage is the information model of the system. This is the model scheme of company power supply (Fig.4).

Energy management systems form a unified organizational and technological platform for managing energy resources in order to develop energy efficiency.

Energy resource management is provided by:
- regulatory and technical and administrative documentation;
- a toolkit in the form of a software-analytical complex, uniting personnel managing energy resources, on the basis of a single organizational and technological platform for the implementation of actions to save energy and improve energy efficiency [17];
- real-time analytical description of the process of consumption of energy resources [18];
- information support of personnel in the form of on-shift data provided to personnel in real time on energy-technological performance for the development and implementation of management actions to ensure and improve the energy efficiency of the work performed;
- the ability to carry out targeted motivation of personnel on the basis of regular every shift information on the actual energy and technological performance [12].
3. Consulting of energy management systems

Consulting and engineering support of EMS is interdisciplinary in content and cross-sectoral in implementation, and is a set of works, including:

1) Analysis of compliance with local regulations of the EMS with the preparation of relevant analytical reports.
2) Consulting on implementation of the Energy Policy.
3) Development of methodological and soft- and hardware support.

There is a necessity at many domestic enterprises in transition to the system covering all complex of interconnected processes of maintenance of the set technical condition of electric equipment within the limits of its reliability and production economy. The given necessity is connected, first of all, with constant growth of equipment quantity being on the balance of the enterprise, and the limitation of existing system of fixed-schedule maintenance which is not allowing providing in full necessary indicators, as from technical, and financial the point of view.

The general problem of the similar system - to provide "logistical" aspect of life cycle of the equipment, that is efficient control of informational (statistics, monitoring and diagnostics data cards, etc.) and material (spare details) flows in space and in time.

The urgency of building of the system lies in the decisions, which allow:

- To raise the control quality over a technical condition of the equipment,
- To provide efficiency and reliability of the received information about the equipment at the operation phase,

**Figure 4.** The model of scheme of the company power supply.
- To increase speed and quality of made decisions.
The authors have the experiences of research, design and implementation of the decision-making systems at the enterprise which basic elements are [13, 15, 17]:
- system of the analysis of the statistical data on the basis of monitoring and diagnostics actions;
- the integrated estimation of the technical condition and the way of facilities operations;
- expert system of forecasting technical condition and the level of reliability of power supply system.

4. Conclusions
The functioning of the EMS provides conditions for the integration of the technical and management components of the energy consumption process based on software and analytical systems for energy resource management with the unification of participants in the energy consumption process on the basis of a single organizational and technological platform for the development of energy efficiency.

The analysis of the subject area in the course of which the functions of the information systems were established, the list of the main documents and business processes of the key departments was identified.

The analysis of the route of documents participating in office work, operational, organizational and other activities was carried out and on the basis of analysis a classification of these documents was developed and a list of their main types was developed.

Consulting support for the functioning of the EMS is interdisciplinary in content and cross-sectoral in implementation, and causes additional specialized labor intensity and the associated need to attract organizations to provide consulting.

The application of the modularity principle gives the system flexibility and scalability. There is the possibility of replacing obsolete modules in the future without changing the others. The use of client-server technology allows you to concentrate data control (security, integrity) in one block (logical and physical) and abstract data management from the user interface. This solution gives the system stability and greatly simplifies data management. The information model of the data constructed at the same stage has the necessary flexibility to meet the current needs of the customer and is designed for possible changes in the list of the main types of documents due to the separation of the concepts “document” and “document attribute”. The system is designed with the expectation of significant changes in the structure of documents and workflow, always reflecting, at the same time, the existing workflow method in the department.

It is assumed that the results of the work will be included in the training course of the new master's program “Digitalization Of Industrial Electrotechnical Complexes” for the training of engineering skills, scientific and management personnel in the power industry and grid companies [19].

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References
[1] ISO 50001:2011 “Energy management systems – Requirements with guidance for use”
[2] ISO 15926 Industrial automation systems and integration – Integration of life-cycle data for process plants including oil and gas production facilities
[3] ISO/IEC 15288 Systems and software engineering – System life cycle processes
[4] Bagajewicz M 2002 The Canadian Journal of Chemical Engineering 80 pp 3–16
[5] Schumpeter J A 2006 Business cycles: a theoretical, historical, and statistical analysis of the capitalist process (Mansfield Centre, Connecticut: Martino Pub.)
[6] Reinersten R 1996 Reliability Engineering and System Safety 54(1) pp 23-34
[7] Aytug H, Khouja M and Vergara F E 2003 International Journal of Production Research 41:17
[8] Cota E V, Gullo L and Mujal R 2014 Proc. of Annual Reliability and Maintainability Symposium 6798454

[9] JSP 886 The Defence Logistic Support Chain Manual Vol 7 Integrated Logistics Support

[10] IEC 60050-191:1990 International Electrotechnical Vocabulary Chapter 191: Dependability and Quality of Service

[11] Larman C 2004 Applying UML and patterns: an introduction to object-oriented analysis and design and iterative development (NJ: Prentice Hall PTR)

[12] Guenter B, Jain N and Williams C Managing cost, performance, and reliability tradeoffs for energy-aware server provisioning (Microsoft Research, Redmond WA)

[13] Petrochenkov A B, Khudorozhkova M A, Lyakhomskii A V 2018 Technological docflow for vendors of energy and automated products: Information system and study case Proc. of 2017 IEEE 6th Forum Strategic Partnership of Universities and Enterprises of Hi-Tech Branches (Science. Education. Innovations) pp 44–47 DOI: 10.1109/IVForum.2017.8246046

[14] Booch G 2008 Object-oriented analysis and design (Moscow)

[15] Petrochenkov A B, Romodin A V, Mishurinskikh S V, Seleznev V V and Shamaev V A 2018 Experience in Developing a Physical Model of Submersible Electrical Equipment for Simulator Systems: Research and Training Tasks on the Agenda of a Key Employer Proc. of 2018 XVII Russian Scientific and Practical Conference on Planning and Teaching Engineering Staff for the Industrial and Economic Complex of the Region (PTES) pp 114-117 DOI: 10.1109/PTES.2018.8604169

[16] Bochkarev S V, Ovsyannikov M V, Petrochenkov A B and Bukhanov S A 2015 Russian Electrical Engineering vol 86 no 6 pp 362–366

[17] Petrochenkov A B and Romodin A V 2010 Russian Electrical Engineering 81 no 6 pp 323–327

[18] Hastings N A J 2015 Physical Asset Management DOI: 10.1007/978-3-319-14777-2_3

[19] Petrochenkov A, Kalinin I, Lyakhomskii A, Leysle A and Zharkov A 2020 About Network Master's Program “Digitalization Of Industrial Electrotechnical Complexes Proc. Of 2020 XI International Conference on Electrical Power Drive Systems (ICEPDS) pp 140–143 DOI: 10.1109/ICEPDS47235.2020.9249080