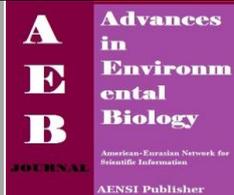




AENSI Journals

# Advances in Environmental Biology

ISSN-1995-0756 EISSN-1998-1066

Journal home page: <http://www.aensiweb.com/aeb.html>

## Base of Instruments for Managing Energy Resources in Monitoring Activity of Industrial Enterprises

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### ARTICLE INFO

#### Article history:

Received 25 March 2014

Received in revised form 20 April 2014

Accepted 15 May 2014

Available online 5 June 2014

#### Key words:

Energy resources, energy saving,  
energy management, energy audit,  
monitoring.

### ABSTRACT

This article gives ground to main elements of base of instruments for managing enterprise's energy resources; reveals organizational aspects of establishing energy management, energy audit and monitoring in industrial enterprises; suggests an organizational functional structure of analytical laboratory for energy saving.

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**To Cite This Article:** Shatalova T.N., Chebykina M.V., Zhirnova T.V., Bobkova E.U., Base of Instruments for Managing Energy Resources in Monitoring Activity of Industrial Enterprises. *Adv. Environ. Biol.*, 8(7), 2372-2376, 2014

## INTRODUCTION

Experience of industrially advanced countries set conceptual approaches to managing energy resources for the purpose of their optimization. These approaches include legal, organizational, economic, geographical, demographic etc. aspects. We believe that these aspects generally depend on administrative base of instruments, containing energy management, energy audit and monitoring.

#### Main part:

For the purposes of establishing energy saving system in any enterprise, energy management should be applied for its activity to provide an integrated approach to structural economy of different types of energy. Energy management in a broad sense can be considered as a general management instrument with a universal set of controls for managing energy consumption and expenses for its obtainment. In a restricted sense, energy management is the scheduled system monitoring and accounting of energy flows with the purpose of expenses for energy consumption being reduced to a minimum.

It is reasonable to use a systematic approach at the heart of the energy management [1]. This approach includes seven successive steps: systematic (dynamic) analysis of general conditions of energy consumption in a company; control and appraisal of a situation at the time (on the basis of the fact); process of making a decision on energy management implementation; energy consumption recording; monitoring and appraisal of energy consumption; informing administration and employees about the results; development of measures on organization, technology and behaviour.

Matters of consulting about energy saving are an important aspect of the energy management [2]. This consulting should include first two steps and provide a fundamental understanding of situation and purposes of inspiring workers and enterprises to apply energy management effectively.

When consulting on the matters of energy saving one should be able to convince people who take a dim view of the very idea of rational use of energy; to engage workers who support energy management implementation, getting priorities right, and also support energy consumption manager's work on collection, monitoring and appraisal of energy consumption.

The key point of most of projects on energy saving is a qualified consulting. Original conditions and possibilities of implementing energy saving program are different in every company. The main aim of organizations, is to reduce discharge of CO<sub>2</sub>, SO<sub>2</sub> and NO<sub>2</sub> into the atmosphere. One of ways to achieve this aim is to convince consumers to lower the energy consumption level. The energy management aim can be represented as the rational use of energy [3]. And this aim should involve not only taking actions on energy economy, but also energy management systematic approach.

*Methods:*

We included aims, instruments (necessary information collection) to the process of energy management plan implementation. This process is a sample model and may be freely developed further.

1- Systematic (dynamic) analysis of general conditions of energy consumption in a company. Its aim is to show conditions and expenses for energy consumption in the form of tables and diagrams.

For this one should collect information on consumption and expenses for energy for the last 5 years: counter readings, suppliers' invoices and administrative data. Then one should carry out the analysis of consumption and expenses for energy consumption with the given calculations in a way to demonstrate saving or overexpenditure.

To obtain analysis results, one should give correlation between energy consumption and building volume and habitants' quantity, thus one can get comparison indicators. Then one should compare level of energy consumption of a certain building with national indices for similar conditions. Then one should correct data of energy consumption for heating according to climatic data, for this purpose one can use a degree-days method, allowing to compare data for several years. Thereafter one should carry out the analysis of data on monthly energy consumption according to suppliers' invoices for the whole year [4].

After studying structure and content of energy suppliers' contracts, one can identify parameters for analysis and appraisal of the current situation. When there are several objects, energy consumption of which should be appraised, one should define priorities.

Data necessary for this process: level of consumption of gas, electrical energy, oil products for a year and their comparison for the last five years, data on energy consumption according to counter readings for a previous calendar year, data on buildings' volume, total floor area, quantity of users, operational expenses and earnings.

To obtain these data, it is reasonable to use form of request filled on the grounds of energy company accounting department's data. However it is not infrequent that inadequate information has been given.

When implementing the initial stage, it is necessary to set the list of data on energy consumption, given by organization's accounting department, and also to estimate degree of reliability of the obtained information, to prepare form of request and report system.

It is important to get an organization interested in giving reliable information. Recording of consumed energy and accounting department calculations are fundamental conditions of energy management implementation at this stage.

2- Control and appraisal of a situation at the time (on the basis of the fact);

3- Process of making a decision on energy management implementation. This step's aim is to implement energy management; to establish cooperation with administration in the sphere of policy and organization of energy management; to promote employees' responsibility for management implementation.

To achieve this aim, it is necessary to convince workers of energy management relevance on the basis of energy consumption analysis data. This can be achieved via reports and workers' appraisal of the situation. Then one should suggest actions on driving down costs and explain obtained benefits.

Administration should decide how energy management can be implemented in enterprise's activity and also to draw up a plan of implementation and then to fulfill it. It should think out a distinct policy with particular goals. Using this approach popularizes the energy management idea.

Energy management should be started with definition of priorities. For this purpose one needs the information about absolute and relative levels of energy consumption in comparison with national indices; about actions that have been previously taken on energy saving; and effectiveness of these actions; about buildings' technical condition [5].

If a high level of electrical energy consumption has been found in separate technological processes, solving of this problem should get the status of a top priority.

It is evident that solving of one problem leads to other changes. For instance, after building's thermal insulation a problem with calculating of a heating network's new power arises etc.

The experience of foreign countries shows that energy management implementation requires just 3-5% of annual costs for total energy consumption. Expenditures in amount of 3-5% are quite acceptable, because energy consumption control allows to get 10% of saving just due to energy management implementation. A project payback period is about six months.

In general, electrical energy consumption manager's main functions are creation of electrical energy consumption records system, energy flows analysis, calculation and control of energy consumption norms, reporting on energy consumption, development of suggestions on new technologies, on investment policy, investment calculation, analysis of energy consumption from the viewpoint of energy saving, planning of actions on improvement of technological process, servicing and equipment's operating conditions.

Energy consumption manager may be employed by an enterprise for a part-time working week or full-time, but if the work takes 20 hours per week it is reasonable that a specialist should have the qualification corresponding to the energy management profile [6]. In this case energy consumption manager should comply

with certain requirements: be sociable, be good at organizational and individual work, be able to analyze, be technically trained.

4- Energy consumption recording. Administration together with energy consumption manager decide which data are necessary. The aim is to collect information on energy consumption to see the enterprise's situation and to appraise effectiveness of actions being taken.

As a result of the electrical energy consumption data permanent recording we can estimate consumption periodicity, compare obtained data with the same period of the previous year and norms of energy consumption.

5- Monitoring and appraisal of energy consumption as a practical matter mean that the energy consumption actual level is controlled on the basis of the norms. The easiest way to determine the standard is to accept electrical energy consumption level in a corresponding month of the previous year as a standard. When determining the energy consumption standard, one should consider certain aspects: one cannot set a low level of the standard, because this can lead to disappointment and its subsequent correcting [7]. A monthly standard should be not less than 10% of the consumption level for the previous year. After performing actions on energy saving the standard should be corrected with account of saving.

6- Reports. Data obtained as a result of the preceding actions should be represented as reports for board of directors, administration, users of a building. However information for administration should be coherent. Therefore it is reasonable to present data in the following forms.

A monthly bulletin on energy consumption. With the help of this report an energy consumption manager informs about results for a month, analysis, energy consumption level changes, actions on lowering this level. The bulletin may be used to inform employees or residents. It can point out ways of energy saving.

Quarterly reports. They help an energy consumption manager to inform administration about the situation with performing actions on energy saving.

Annual report includes obtained results and planned figures. The report is intended for administration and energy management group. This reporting form is an efficient instrument for monitoring the reaction to actions taken for energy saving. The report should be oriented towards different groups of information consumers. They can be classified according to the following report's users: top management, accounting department, middle management, various working councils.

Annual report includes the following sections: analysis of actions on rational use of energy, with reasons of increasing or lowering of electrical energy consumption level, default figure of energy consumption for existing equipment, corrected fuel and energy balance, list of priority actions of energy saving policy [8]. Annual report cannot be made in contracted form, because to prepare it, one needs to have data and experience of an energy consumption manager.

7- Development of measures on organization, technology and behaviour. Energy management studies and regulates matters of organization, technology and behaviour. Actions are taken only in one of the specified spheres. A good result can be achieved if actions are carefully thought-out and well-balanced. The following actions fit into the group of organizational ones: organization of activity, premises cleaning, rational use of contract terms, requests for reports on actions taken, maintenance service control, controlling on the basis of data on energy consumption, methods of equipment setup, attracting of employees to registration of complaints.

The second element of the conceptual approach to energy resources management with the purpose of their optimization is the energy audit. Energy audit allows to perform, to analyze use of energy resources and their price, to identify places of their irrational use and on this basis suggests the energy saving program for an enterprise [9]. Among energy audit aims we can mention the following ones: appraisal of energy resources consumption in organization and development of actions on promoting energy saving projects. On the basis of this information one should make a comparison with different enterprises of the one branch.

Energy audit methodology includes six stages:

1. Calculation of energy consumption and expenses: enterprise inspection performed by means of analysis of information on energy consumption, planning of actions.
2. Estimation of energy flows: balancing of energy resources, identification of main consumers and sectors of possible saving of energy resources.
3. Studying energy flows and suggesting actions on energy expenditure reduction.
4. Designing projects on energy saving – studying suggestions on energy saving, comparison of alternatives and choosing best ones.
5. Analysis of energy saving projects via appraisal of projects' implementation consequences, their practicability, cost and recoupment.
6. Presentation of obtained results: making written reports on administration's energy inspection results.

Energy audit should not be considered as just a technical problem. It should have legal and economic grounds. "Rules of carrying out energy inspections of organizations" regulate carrying out energy inspections of organizations to estimate efficiency of resources use, and such inspections should be performed for all enterprises where energy resources consumption is more than 6 th. tonnes of reference fuel, at least once in a quinquennium.

The energy management problem is the absence of the organizational structure which bears responsibility for energy efficiency in an enterprise. Energy manager position is an administrative position, and it cannot have understanding without administrative mentality.

Actions on energy saving require investment, but at the same time they may be costless, not requiring investments for new equipment, but allowing to change working methods. The reason for long-term projects implementation may be not only energy consumption decreasing, but also new production release, increase in output, reduction in environmental pollution. Low-cost measures are impossible without understanding of the process of energy use in an organization and without controlling this process.

Here we should note that nowadays due to the RF Government Ordinance of the 31<sup>st</sup> of December 2009 № 1225 “Requirements for regional and municipal programs in the sphere of energy saving and energy efficiency raising” it is prescribed that regional and municipal programs in the sphere of energy saving and energy efficiency raising should contain a list of target indicators in the sphere of energy saving. We offer to divide them into 7 groups: integrated indicators in the sphere of energy saving and energy efficiency raising with account of goals; indicators in the sphere of energy saving and energy efficiency raising, which allow to estimate saving for each type of energy resources with account of goals; indicators in the sphere of energy saving and energy efficiency raising in a budgetary sector with account of goals; indicators in the sphere of energy saving and energy efficiency raising in housing facilities with account of goals; indicators in the sphere of energy saving and energy efficiency raising in public utility infrastructure systems with account of goals; indicators in the sphere of energy saving and energy efficiency raising in a transport system with account of goals; other target indicators.

#### Results:

We believe that in a certain methodical complex presented indices may be included to the control and registration instruments set of energy management function. But for a more fundamental analysis of current and strategic tasks of the energy management one needs compound indices that can belong to both monitoring and energy audit. And therefore we agree with the viewpoint of some researchers (1, 2, 3, 4) who prove that a generalizing criterion of the enterprise’s energy management efficiency is a maximum of the energy efficiency index  $E_f$  (formula 1):

$$E_f = S_v - \Delta LE + S_m (E_{pe} + E_{ef} + T_e + E - (R_{se} + R_{ss})), \quad (1)$$

where kWh(Gcal)/rub

$R_{ss}$  – revenue from sales of energotechnological services in energy markets;

$R_{se}$  – revenue from sales of energy generated with own stations;

$E$  – other expenses connected with violations of security and quality of external energy supply;

$T_e$  – total expenditures for exploitation and management of energy facilities;

$E_{ef}$  – expenditures for purchase of energy fuel;

$E_{pe}$  – expenditures for purchase of energy;

$S_m$  – supply to external markets;

$\Delta LE$  – loss of energy in generating stations, transforming stations, electrical and heat networks of energy facilities;

$S_v$  – sum of volume of purchased and produced (in own stations) electrical and heat energy (for own consumers).

Where there are combined heat and power production plants (CHP) in enterprises, volumes of heat energy and electrical energy in the index  $E_f$  should be measured in one and the same unit. In particular, 1 kWh = 860 kcal is used in practice. Energy efficiency should be analyzed in dynamic.

Thus, formula 1 in complex accounts such factors which determine energy management efficiency – energy saving, economic exploitation of energy facilities objects, optimum solution of suppliers of fuel and energy, (own) energy potential. But analysis may require additional parameters. Energy business efficiency coefficient (formula 2):

$$C_{ef} = R_{et} + R_t / E_t, \text{ where} \quad (2)$$

$R_{et}$  – revenue from sales of electrical energy (heat energy), produced with the own generator;

$R_t$  – revenue from sales of technological services;

$E_t$  – total expenditures for energy supply (for product costs – calculation for a period).

Coefficient of self-sufficiency of electrical and heat supply (formula 3):

$$C_s = V_o / (V_o + V_p), \text{ where} \quad (3)$$

$V_o$  – volume of own generation of electricity (heat) for an account period;

$V_p$  – volume of purchased electrical or heat energy;

Coefficient of share of secondary energy resources in enterprise's energy supply (formula 4):

$$C_s = V_g / (V_o + V_p), \text{ where} \quad (4)$$

$V_g$  – volume of generation of electrical (heat) energy on the basis of enterprise's secondary resources.

New strategies of enterprises' behaviour in energy markets require energy management work redesign, hence the problem of projection and implementation of corresponding organizational structures becomes especially burning. We consider creation of a specialized system of energy saving management and its structural analytical department (namely an analytical laboratory) to be reasonable for electrical energy and industrial enterprises. Main functions of the analytical laboratory are: general management of energy supply in a factory; organization of the work on implementation of advanced technical solutions in the energy saving sphere during introduction of new and exploitation of existing energy stations and systems, and also on increasing of level of secondary energy resources using; factory's units heads' controlling work of all energy saving management system's elements; organizational methodical work on preparing management solutions in the energy saving sphere and control of their implementation; development of instructions, recommendations, methods and other normative documents according to energy saving work; organization of development and feasibility study of current, medium-term and long-term plans on decreasing expenses for fuel and energy resources (FER).

#### Conclusion:

Thus, we studied conceptual approaches to managing energy resources, which are boiled down to three interdependent elements – energy management, energy audit and monitoring. Instruments set of energy resources management should be implemented at two levels in coordination – a technical level and an administrative level. The aim of the technical one is to create an informational system. Here we can mention energy audit and monitoring. The aim of the administrative level is to create a management structure, which is responsible for information support and development of necessary actions (also on the basis of monitoring). In other words, monitoring is an intermediate element in conceptual approaches to energy resources management, which we can define as a way (method, mechanism) to compare results (information) with assigned tasks (actions). We studied the instruments set elements mostly at the enterprise's level. We believe that an enterprise is a certain "catalyzer", which shows practicability and possibility of implementing some mechanisms at a regional level.

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