IMPROVING ENERGY MANAGEMENT IN THE FOOD INDUSTRY USING THE MOTIVATIONAL AND PREDICTION FACTORS EVALUATION AND ENERGY EFFICIENCY MEASUREMENT SYSTEM

Phd Student Corina GRIBINCEA
National Institute for Economic Research of the Academy of Sciences of Moldova,
Republic of Moldova
Email: corina.gribincea@gmail.com

Abstract. *The article addresses the topics of energy efficiency management, starting from energy system modeling of an enterprise from food industry through the motivational system improvement, predicting and measuring energy efficiency. Based on the survey were determined the main directions of energy savings and have been specified preconditions for the study, particularly the special features of each process, location, technical age of technological equipment, experience and knowledge of personnel, including criteria-factors that influence the energy efficiency of an enterprise. In the article are determined the axes of enterprise energy consumption and proposed energy efficiency measures for industrial processes.*

Keywords: *energy management, food industry, motivational and prediction factors, measurement system of energy efficiency.*

JEL Classification: *L66, O13, Q43.*

1. Introduction

Understood as a model of economical consumption of energy resources, the efficiency of the industrial enterprise energy model, including the food industry, can be organized in several ways. Successfully is used efficient update of technological processes and of enterprises from food industry. Effective results are obtained in the reconstruction of energy supply systems of the enterprises and industrial facilities.

The chosen path that would allow effective organization of saving energy resources depends on the individual characteristics of specific enterprises, own energy policy and the stipulation of energy consumption saving program, incentives and policy management for local authorities. An additional reason appears in terms of limiting access to energy, however, this problem usually is complex tackled and the concept of economical industrial energy consumption is perceived as one of the directions of cost reduction. Therefore, developing and implementing special programs helping to organize the efficient energy consumption represents the best option for solving the energy problems of the enterprise.

2. Fundamental issues in implementing energy management systems

One of the fundamental issues in the implementation of the energy management systems represents the motivational approach. The main motivation of economical consumption, in general, can serve financial and energy concept. The results analysis of our survey regarding the reasons for the energy management effort showed that 94% of the respondents supported the idea of financial concept and only 6% the concept of energy security and environment.

Resolving the issues of energy economic use within the enterprise is possible through implementation of measures and drafting its own normative base, because the main causes of wasteful use of energy resources and fuel in the enterprises are presented by the low level of application equipment, unregulated station of the technological process, unreasonable use of lighting, poor organization of work, including use of outdated technologies and equipment. According to the conducted survey by the author, main directions of energy saving in vision of the managerial staff within the enterprise are shown in the Figure no.1.

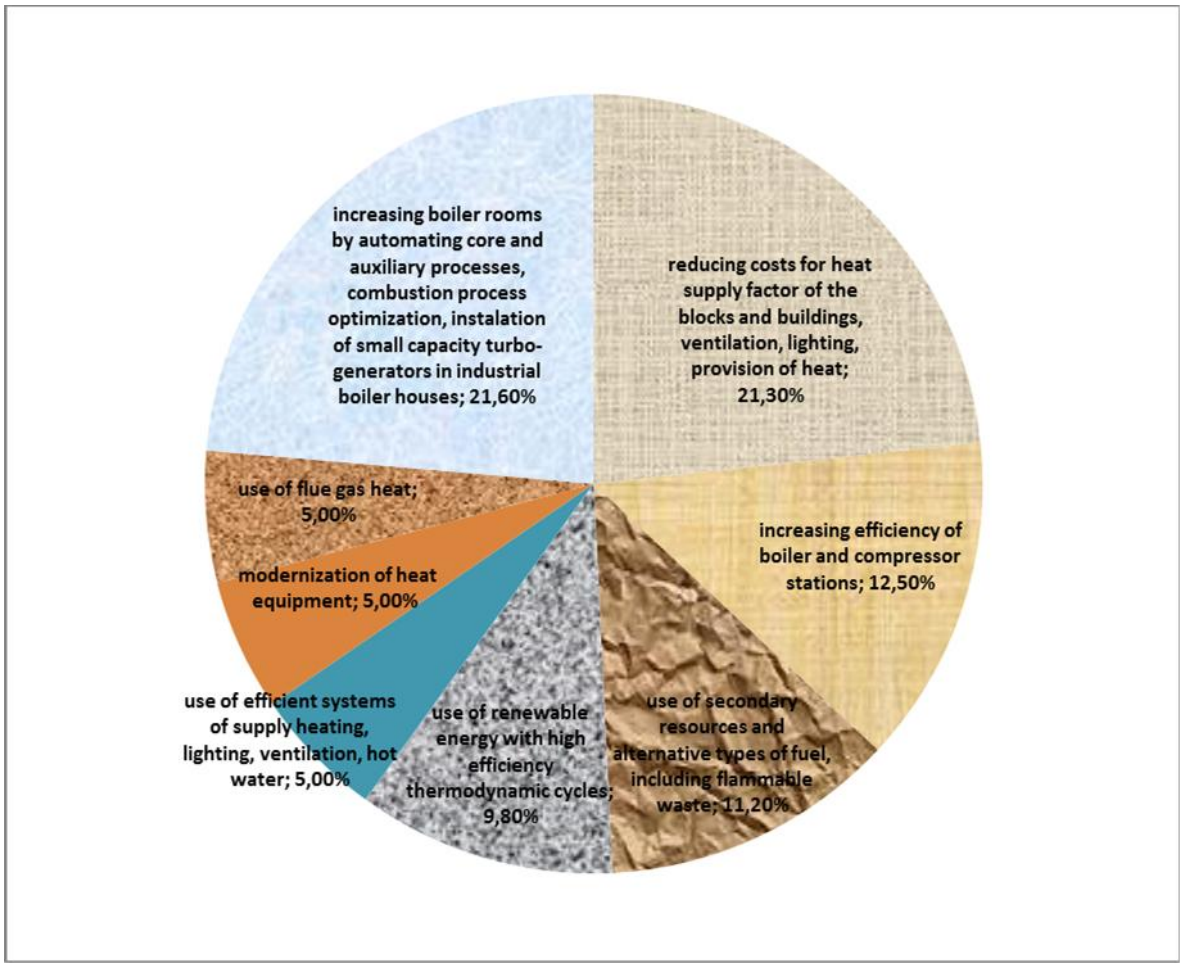

Figure no. 1. The main directions of energy savings in the opinion of managerial staff in investigated enterprises

Source: author's investigations

The analysis of survey results confirms non-compliance status of contemporary norms of electricity and heat consumption necessary for the production. In the implementation of advanced technologies with low energy consumption exist reserves, because in addition to devices with the return of 90% or more, operates a large number of thermal devices with a much lower yield, often not more than 30%. Therefore, attention should be paid in subsequent managerial act not only to physical energy economy and spending cuts, but also on practical training program to stimulate the saving of energy resources.

Taking into account that economic growth model of the country is reoriented from the increase of production volumes by increasing the burden capacity production to scale construction of new capacities and innovative development, management of energy resources kept some peculiarities, conditioned by particular way of the national energy complex development, in particular, the scarcity of energy resources, worn and outdated equipment; also one of the issues most inert is: received funds are poorly invested in the modernization and deployment of production with low power consumption, organizational and technical measures oriented towards increasing energy efficiency, for example, fitting centers of evidence-node power consumption and heat factor delivery, replacement of existing heating systems with local one, installation of electro-thermal generators etc.

3. Implementation of energy management techniques in the enterprises from the food industry of the Republic of Moldova

In order to achieve and implement techniques for energy management within enterprises from the food industry of Moldova is particularly important the principle of selective application of technologies with low energy consumption, which means carrying out activities to reduce energy consumption for certain types of energy resources or objects from the enterprise and it will produce maximum economic effect. In such a perspective it is necessary to determine the factors, which influence substantial the energy system and development of energy model based on the study with low power consumption and increased energy efficiency. Otherwise, shaping an energy system must be preceded by a study of factors affecting and determining whether these influences and dependencies.

The need to identify *factors predicting energy efficiency* in the food industry by factor analysis with modeling multifactorial model was driven by very wide and extensive subject, which is the theme of energy efficiency development. The essence of the model is to create a mathematical dependence between factors determined by an interview organized after certain algorithm.

Based on conducted interviews at 21 Moldovan enterprises from food industry, the purpose was to determine measures to improve energy efficiency (Figure no. 2) unique to analyzed enterprises. For this were mentioned special features of each process, location, technical age of technological equipment, staff experience and knowledge.

These preconditions are necessary to make the quality of the study, thus geographical location defines specific characteristics of climate and natural resources (raw materials, etc.) of the place (zoning agricultural raw materials, technological properties and consumption of agricultural production for food industry) and manufacturing processes and final product quality specifications create limiting conditions for energy efficiency.

Technical age of the production line is often neglected, so when planning a new production line, it is possible to improve energy efficiency monitoring in effectively way, because many concrete actions have not been made.

Also, there are many control systems and methods used in new machinery and production lines compared to older ones and experience and knowledge of staff may be insufficient compared to those used at optimization process in production lines being in operation throughout the years or for development of documentation practices and dissemination of energy information.

Figure no. 2. Steps to improve energy efficiency in enterprises from food industry
Source: author's elaboration

As resultative indicator Y was selected one of the company's energy efficiency indicators (specific costs of 1 MDL of production). As criteria-factors X_1, X_2, X_3, X_n that influence the resulting criteria are established following key indicators (Table no.1).

Table no. 1. Criteria-factors that influence the resulting criteria

Criteria-factors that influence the resulting criteria	
X_1	production volume, thousand MDL
X_2	expenses for operation of energy supply, thousand MDL
X_3	volume of investments in energy management programs, MDL
X_4	the number of enterprise staff, persons
X_5	average salary, thousand MDL
X_6	production of energy resources, fractional units
X_7	specific consumption of production materials, MDL
X_8	average duration of the shift at the enterprise, hours
X_9	average category of the production workers
X_{10}	number of production subdivisions
X_{11}	total surface provided with energy, s. m.
X_{12}	coefficient of request equipment
X_{13}	energy coefficient endowment of the labor, kW / pers.
X_{14}	equipping labor with fixed capital, thousands MDL / pers.
X_{15}	share of the equipment in the value of fixed capital

Source: adapted according to Сергеев Н. (2013)

The group of experts was constituted of 10 members, which consisted of enterprise managers and directors, including workers that respond of energy training, technological and economic production. Each expert weighted proposed factors. Each criterion was assigned a rank as a natural number. Expert advice degree of concordance was determined according to the value of the Kendall coefficient W = 0.927. Following the results were systematized weighting factors examined by the level of their influence on the energy efficiency of the company as follows:

1) specific consumption of materials of production (factor 7) - rank sum is 21;
2) volume of investments in energy management programs (factor 3) - rank sum 22;
3) production of energy resources (factor 6) - rank sum 25;
4) expenses for operation of the power supply of the enterprise (factor 2) - rank sum 41;
5) volume of production (factor 1) - 43 rank sum.

The data were compared with data from the method of regression analysis. Criteria-factors selected by the a priori weighting method were compared with the resultant Y, thus evaluating the factor's role in the model formation, the presence of the relationship, the relationship level and the level of essentiality. As result was determined that energy efficiency affects many factors, most influential were two factors - reducing specific consumption of materials of production and improve the provision of the enterprise with its own energy resources. The closely related factor was recorded between resultant criteria - factors 7 (specific consumption of production materials) and factor 6 (manufacture of energy resources). Based on this model may be developed for the enterprises models of energy efficiency and recommended energy efficiency measures savings.

It is obvious that knowledge and application of principles of sustainable development by industrial management are weak, local food enterprises are behind foreign companies according to energy endowment and insurance with resources; and the task of sustainable development of the modern food enterprises (impossible without the implementation of production processes with enhanced energy efficiency and high technology) must be addressed for food production taking into account the achievement of energy savings and resources of different levels.

Thus, the first level is performed with high efficiency choice of nanotechnologies. Type of processes of level 2 affects industrial structure and technological equipment of food production. Often the task of saving energy and resources of level 3 is resolved by developing and implementing multi-type apparatus and machines of new type. Later production efficiency can be enhanced by automation technology and minimize costs in the supply systems of enterprises. The main focus at the same time is attracted to the record of resource consumption and reduces energy losses in the environment based on regenerative heat schemes, processing secondary raw materials, the implementation of recycled technologies or with reduced scrap, manufacturing energy-efficient blocs, using renewable energy (Слесаренко, 2008, pp.46-47).

Gas and heat are considered the largest carriers of energy in enterprises; a considerable share in the consumption of energy resources lies to natural gas, used in the manufacture of heat. Boiling products before and after conservation is one of the processes with the highest energy consumption in the food industry, which lost more than half of the total heat consumption. Average specific consumption of electricity from food industry varies by product type (Table no. 2).

Table no. 2. Average specific consumption of electricity for some products from food industry

Products from food industry	Measurement units	Average specific consumption
Meat	kW × h / ton	57
Sausage	kW × h / ton	75
Flour and cereals	kW × h / ton	58
Vegetable oil	kW × h / ton	160
Canned fruits and vegetables	kW ×h/ thousand jars	23
Sugar (sugar beet)	kW × h / ton	25
Processing raw sugar	kW × h / ton	76
Milk	kW × h / ton	11
Bread and bakery products	kW × h / ton	25
Lees	kW × h / ton	2910

Source: adapted by the author according to Вагин Г.Я. (1998)

Huge expenditures for construction and operation of modern systems of conditioning and ventilation systems require the search for new ways of saving resources and perfecting all types of heat in buildings. In summer time up to 80-85% of cold air and exhaust ventilation in rooms can be returned to the system and used to cool the outside air input. The recirculation of cold air and heat economy is achieved by reducing processed outside air, while the amount of air circulation in the system does not change necessary to ensure the mobility of air into the room.

A certain economy of heat and cold conditioning systems can be achieved by using variable air intake systems. Technical solutions of variable air intake systems involve the use of complex ventilation equipment cutting performance and management means that ensures optimal algorithm of energy consumption and costs equated to operating system. A

superior thermal energy saving ventilation systems and air conditioning can be achieved by using waste heat from high temperature dryers, boilers and systems of cooling technological equipment.

Raising the potential for heat through the implementation of thermo-pump devices (a device for transferring heat from low-temperature sources to the subject of higher temperature) in supply systems of "heating-cooling" factors of enterprises are linked to spending a certain type of energy (mechanical, electrical, thermal, gas or steam flow etc.).

Secondary energy resources represents a potential of a certain type of energy (thermal, chemical, mechanical, electrical) contained in waste, intermediate or finished products. Secondary energy resources of enterprises can be divided into four groups, the greatest importance were the first two groups of secondary energy sources:

1. heat of gas and burning liquids;
2. steam exhaust heat of power plants with steam and steam devices;
3. flammable waste heat;
4. heat contained in products and production waste.

In the production of bakery, confectionery and secondary energy resources starch elements are: condensates heat, steam-vacuum secondary devices, serpentine necklaces, water pressure, steam evaporating secondary devices, exhaust gas furnaces, dryers and boiler rooms. In the production of alcohol, as secondary resources are used thermal heat hot mash column, fermenting mash, secondary-products production, heat condensers, water reflux and secondary steam dryers yeast, water cooling of the condensers and refrigerators, hot air production premises, the exhaust gas scrubbing water.

National and international experience demonstrates that energy costs saved as a result of reconstruction is 3-5 times lower than the construction of new energy obtained from similar devices. It is quite cost-effective use of heat of combustion of natural gas products. After the amount of burned fuel in ovens, bakery production is of central importance in the food industry. On average, for baking a ton of bread is necessary 50-65 kg of conventional fuel. From this quantity of fuel is only 30-32% effective part. Together with the combustion products into the atmosphere reach from 30% to 60% of the total quantity of heat. Temperature of flue gases from furnaces, heating pipes ranging from 500 to 700C, whilst ensuring thermal stress of furnace gases at a temperature combustion of 350C, which causes the possibility of its use for heating the air before submitting it to the oven and not only saves fuel, but also improves the combustion conditions. In addition, heated air temperatures increase by 1C conditional decrease symmetrical temperature smoke gas. Further the exhaust gases can be used in the heat exchanger for heating water contact. Such a deeper gas cooling furnace can sharp increase the heat utilization coefficient of the fuel.

The use of secondary energy resources for domestic greenhouses heating of enterprises from the food industry is one of the directions weakly exploited. For greenhouses placed on industrial enterprises territory can be used the exhaust gases of technological equipment (heating furnaces, dryers etc.) and boilers with high temperature including hot water or steam of technological equipment. High-temperature of hot water is used in traditional systems of greenhouses heating and water at low temperature - the switchgear contacts for heating and humidifying the air, transmitted in greenhouse.

Given the primary equation of the food industry, where the main product is only 15-20% of the initial feedstock and the rest becomes waste from production technologies, main task is to increase the level and depth of raw materials processing, ensuring the best possible use of all its components. The use of secondary raw material resources not only improve the ecological situation due to the decrease in industrial waste but also increase efficiency of given industry, generally by obtaining additional nutritional components.

The number of challenges facing the food industry, require implementing the best solutions for conversion into businesses and seek constantly for solutions to optimize its potential in front of the new models to enhance competition in terms of increased food production in keeping up with demand, while preserving essential ecological integrity of production systems it is huge both in scale and complexity. In terms of production nomenclature diversified and the competitiveness of the Moldovan food industry determined by unskilled management or lack of management regularly able to provide efficient and flexible sector under conditions of high competition by price and regardless of speed movement environment factors, a tool to ensure record power consumption is considered the system of energy performance indicators (EPI), which together with the use of measuring technique allows assessing the level of organizations from different branches and areas after differentiated consumption of energy for each type of production or comparing the level of technology at all levels. Using Internet module allows monitoring the level of energy consumption over time and tsb-mobile applications determining the quality level of energy benchmarking.

4. Monitoring and reporting energy efficiency

Monitoring and reporting on energy efficiency is not a new problem in the energy industry. The best available techniques for energy measuring and monitoring were defined in the reference document of the European Commission and are classified as follows:

- direct measurement of energy efficiency;
- indirect measurement of energy efficiency.

An example of direct measurements of energy efficiency is the flow of electricity or heat from a system. Indirect measurement indicates the level of energy efficiency, but does not provide an exact level of energy efficiency. In order to use the data effectively from the measurements, it is important to have sufficient measurements in the process, and that they be in the correct position and continuously calibrated. Measuring electricity is good practice to define the lowest power level at which measurement is required.

In terms of energy efficiency, it can be said that in general, monitoring and reporting are not only technical issues but also contain many psychological elements. The user is always in focus and only very few processes can be controlled and optimized. The best results can be achieved when energy efficiency is a critical part of everyday of every employer.

Calculation of EPI indicators, the limitations of the system, are important in understanding the methodology of benchmarking energy, but differences between companies of the same class can be quite representative, and only attract more organizations in this system will allow some smoothing of data certain classes of business, types of processes or production. To increase the efficiency of the food industry, it is proposed to set up a managerial mechanism of benchmarking under the system of energy performance indicators, which would allow evaluation of the organizations level after consumption of differentiated energy for each type of production, and improving informational policies in the field with identifying best companies and structural subdivisions.

Energy savings are calculated on the basis of the variation of energy efficiency indicators, compiled using aggregated data from national statistics and define the economy in general, a sector or sub-sector (industrial process, mode of transport and end use , etc.). The method evaluates the total energy savings regardless of the factors that determine them (energy prices, autonomous or policy measures etc.). Efficiency indicators are considered macroeconomic indicators: economy as a whole; economic sector (industry, services, transport etc.); a type of end use (space heating or cooking in the household sector, freight

and passenger transport etc.); and taking into account three types of indicators: indicators to monitor energy efficiency trends; comparative performance indicators of energy efficiency between a country and other countries; diffusion indices which measure the market penetration of efficient technologies and practices.

We should mention that the possibility of using energy-intensive type indicators for calculating energy savings achieved through the implementation of energy efficiency programs are still low. Energy intensity indicators are mainly economic indicators and their ability to describe the technical phenomena is reduced. Thus, in developed countries during the next two oil shocks of 1973 and 1979 was recorded phenomenon known as "decoupling economic growth from increasing energy consumption" and the sharp decline in energy intensity. This was achieved largely through the restructuring of the economy as a whole.

It may be mentioned that since 2011, the Moldovan industry was the beneficiary of a series of actions directed to: development and implementation of program monitoring, verification and benchmarking of energy efficiency, developing and implementing the national program for the dissemination of best practices energy efficiency, capacity building, development of tools and their application in industrial systems optimization and energy management; it was also promoted the concept of energy management, implicit energy savings that can be achieved by the implementation of ISO 50001 (The "Reduce Gas Emissions Greenhouse by Increasing Energy Efficiency in Industrial Sector in Moldova", 2010-2013). Mihail Stratan (2016) noted that the study included the performance of local companies in the following branches: dairy, canned, sausages and the bakery, including JLC JSC, with annual energy savings 0.9% (106 MW), Lactis JSC have annual reduction of electricity consumption by 3.9% (12.3 MW) and annual reduction of natural gas consumption by 22% (229 MW). Participated and other enterprises such as the Urban Buses, Giurgiulesti International Free Port, Termoservice JSC, CET-2 Chisinau, Inlac dairy factory.

5. Conclusions

The efficiency of the energy model of industrial enterprise, including the food industry, understood as a model of economical consumption of energy resources can be organized in several ways. The author believes that the chosen route, which would allow effective organization of saving energy resources depends on the individual characteristics of specific enterprises, has its own energy policy, the stipulation of energy consumption saving program, incentives and policy management for local authorities.

The study of main motivation of economical determined consumption based on the financial concept, energy security and environmental analysis and survey results conducted by the author found that 94% of respondents supported the idea of financial concept. After the end of survey were established main directions of energy saving vision of the managerial staff of the enterprise. Analysis of survey results confirm non-compliance status of contemporary norms of consumption of electric and thermal energy necessary for the production process, so a separate attention in managerial act should be paid not only to physical economy of energy and cuts costs, but also formation of specific programs to stimulate savings of energy resources.

The need to identify factors predicting energy efficiency in the food industry by factor analysis of modeling multifactorial model was driven by very broad topic and represents the theme of energy efficiency development. Based on interviews conducted on local enterprises were determined measures to improve energy efficiency, unique for the food industry enterprises according to the particular characteristics of each technological process, location, age, technical technological equipment, staff experience and knowledge.

The results of weighting factors allowed their systematization by the level of influence on the energy efficiency of the enterprise. As a result it was determined that the greatest power that influence energy efficiency are two factors - reducing specific consumption of materials of production and improve the provision of the enterprise with its own energy resources.

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