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The Impact of the Enterprise Management System on the Energy Efficiency of Auxiliary Processes

Łukasz GRUDZIEŃ[1], Filip OSIŃSKI[2]

[1] *Poznan University of Technology, Faculty of Mechanical Engineering, Poland*
[2] *Poznan University of Technology, Faculty of Mechanical Engineering, Poland*

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Abstract
The consumption of various forms of primary and secondary energy is one of the main sources of greenhouse gas emissions to the atmosphere. Also, the increase in the prices of energy resources is an important factor affecting the economic profitability of running a business organization. Legal requirements in the European Union also affect the need to implement appropriate solutions aimed at increasing energy efficiency, which translates into the need of implementing Energy Management Systems, based the ISO 50001 standard, in many enterprises.. In the case study presented in the article, which is based on a company from the energy industry in Poland, the most important Energy Performance Indexes and the impact of the quality of their information on the results obtained were reviewed. In the analyzed example, the main process used only 28% of the total energy consumption in the organization. Insufficient attention to auxiliary processes led to an undercut of Energy Performance by nearly 11% in the first year of operation. It is partic-ularly important to properly collect data on auxiliary processes, which are very often omitted or treated in general in companies, and as shown may constitute a significant share in the total amount of energy consumed.

Keywords
Energy Management System, ISO 50001, Data quality, Energy Performance, Positive impact on the environment.

Introduction

The energy efficiency of a company, in most cases, should be considered in terms of its production processes, due to their significant share in energy use (Antosz et al., 2016; Antosz & Stadnicka, 2017; Kujawińska et al., 2018; Rewers et al., 2018; Trojanowska et al., 2017; 2018). Due to the significant increase in the cost of energy raw materials in recent years, each company should focus its attention on the costs related to energy use, not only in production processes, but in all implemented processes in order to remain competitive. This is mostly important in the case of production enterprises, where energy costs can absorb 15–30% of all production costs (Giacone & Mancò, 2012). Apart from the issues related to energy efficiency and the ratio of profit to costs (Zerbst, 2018), the reduction of energy use translates directly into the improvement of the natural environment, by reducing the emission of greenhouse gases (McKanne, 2009). A significant part of gas and dust emissions to the atmosphere is related to the generation of energy for industry and transport. The awareness of having such a large impact on the environment, especially by burning fossil fuels, has become an area of public interest. Customers more and more often pay attention to the aspects related to the ecological footprint of the goods they buy, which means that enterprises more and more often decide on solutions aimed at improving energy efficiency in order to improve their own image. Energy efficiency is not only part of the general trend of taking care of environment, especially in the EU, but it is also an element of the wider issue of CSR (Corporate Social Responsibility) (Lindgreen & Swaen, 2010). As part of creating the vision of an environmentally friendly enterprise, companies often choose to present their own energy performance. In most cases, it is related to the Energy Management System implemented in the company based on the ISO 50001 or EMAS standard, but each time the company's care for the environment is emphasized. The reduction of energy use brings additional bene-

Corresponding author*: Filip Osiński – Piotrowo Street 3, Poznan, 61-138, Poland, e-mail: Filip.osinski@put.poznan.pl*

fits related to the reduction of the use of raw materials, but also the reduction of greenhouse gas emissions (Finnerty et al., 2017). This problem was recognized by the EU commission, which is implementing legal solutions to accelerate the process of improving energy efficiency. One of the examples can be the 2020 climate & energy package (European Commission, 2018). It assumes 20% reduction of greenhouse gases emissions, with a simultaneous increase in energy efficiency by 20% and a use of renewable energy sources in the entire energy generated in the European economy at the level of 20%. These were one of the basic goals to be implemented by the end of 2020 for the member countries of the European Union. Energy efficiency is one of the main problems of Polish companies. It is related both to the lack of knowledge about the requirements for the economy as a whole, but also to the lack of knowledge of system solutions allowing for the improvement of energy efficiency (Osiński, 2019).

The problem of energy efficiency was also noticed by the International Organization for Standardization, which issued in 2011 ISO 50001 – standard which contains requirements for planning, implementation and maintenance of the Energy Management System in organizations (EN ISO 50001, 2018). The scope of the first edition of ISO 50001 issued in 2011 had similar assumptions with other management system standards. It described basic concepts such as energy policy, operational planning and control, internal audits and management review. In 2018, the standard was inscribed in the High Level Structure system, which resulted in the new edition of ISO 50001:2018. As part of the changes made, the main one was the application of standardized 10 point layout allowing for easy integration with other management systems. The purpose of the standard is to improve of company energy performance (Gopalakrishnan et al., 2014; Fuchs et al., 2020; Plis & Ociepa, 2020). ISO 50001 provides a range of requirements that support organizations in:

- development of energy policy for more efficient use of energy,
- setting goals, targets and objectives to meet the policy,
- use of date to improve decision making process
- results measurement,
- energy policy and its effectiveness review,
- continuous improvement of EnMS and energy performance.

Despite the numerous requirements of the ISO 50001: 2018 standard, for many companies it becomes a problem to determine the level of detail for the newly built Energy Management System. Also, a relatively small number of publications on the methodology of building a system of this type and the adaptation a specific indicators may be a challenge for many organizations.

In the publication, the authors present good practice in the implementation of an Energy Management System based on the ISO 50001:2018 standard and describe the relationship between Energy Performance Indexes. Based on the data collected in 2017–2020, the need to build comprehensive systems was also presented. The results section describes the impact of auxiliary processes on the overall energy performance of the organization.

Methodology

The research was carried out on the basis of a case study of a large enterprise from the energy industry in Poland. The company consists of 16 main branches, more than 300 branch offices and employs approximately 22,000 employees. The research was carried out on the basis of observation of the company by a group of experts, both as a whole and in individual branches, over the years 2017–2020. In the presented study, the group of experts consisted of academics from the Poznan University of Technology and consultants with many years of experience in implementing Management Systems, with particular emphasis on Environmental Management Systems and Energy Management Systems.

The input data, presenting the state of the company, at the time of starting the research, were collected in the energy audit at the end of 2017. These data were used to determine energy performance indicators for individual processes functioning in the organization. Also, on its basis, the energy goals were set. They were aiming at reducing the amount of energy used in the next years, and were planned for implementation for years 2017–2018. In 2017–2020, internal audits were also carried out, performed by company internal specialists, with the support of outsourced experts. The purpose of the audits was continuous control of the quality of information provided to the management of the EnMS, the ongoing implementation of the system provisions and the control of the implementation of energy targets set for the described period. The summary of this research period is the energy audit carried out in the second half of 2020. During this audit, attention was focused on changes in energy indicators in individual areas of the organization's operation. Particular attention was paid to the reliability of selected indicators, but also to changes in the functioning of individual processes in relation to the energy targets, which were set in 2018.

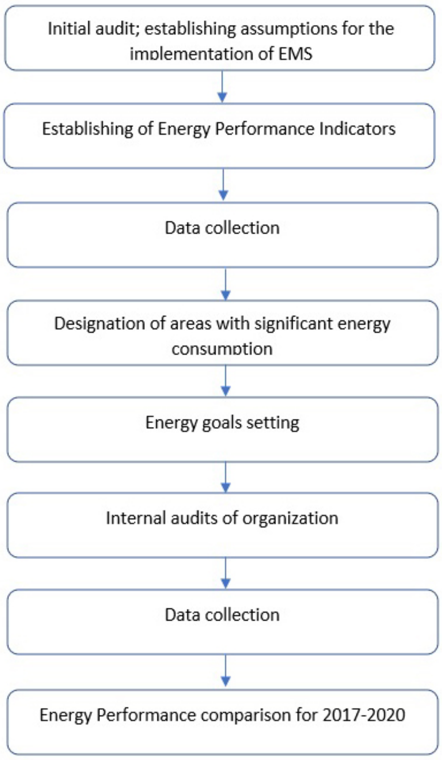

Fig. 1. Graphic scheme of research methodology (own work)

Proposed energy performance indicators

The complexity of the production processes, the number of branches and departments, and the complexity of the company's organizational structure forced the use of a large number of Energy Performance Indicators. A relatively large number of indicators, along with appropriately selected variables influencing the amount of energy consumption in individual areas, allow for detailed energy management and setting precise goals, allowing for subsequent savings and reducing the energy consumption. All Energy Performance Indicators (EPI) used in the presented enterprise are described in Table 1.

Assumptions for the implementation of the Energy Management System

One of the basic problems during the implementation of the Energy Management System in the discussed company was the reliability of the available information on the places and size of energy consumption and the degree of fragmentation of the organiza-

Table 1
Energy Performance Indicators (EPI) and its variables in EnMS

Energy source	Place of usage	Energy usage	Variables	EPI
Electricity	Buildings	Indoor lighting	Daytime length	kJ/m^2
		Cooling and ventilation	Daytime length	kJ/m^3
		Outdoor lighting	Daytime length	kJ/m^2
		Heating and hot water	Outdoor temperature	kJ/m^3
	Server rooms	Power supply	Monthly server load	kJ/number of computer stations
Gas energy	Buildings	Heating and hot water	Outdoor temperature	kJ/m^3
		Gas stove	Non	kJ/number of employees
		Air conditioning	Outdoor temperature	kJ/m^3
		Process execution	Outdoor temperature	kJ/income
		Gas losses	Outdoor temperature	kJ/income
Liquid fuels	Vehicles and machines	Construction machinery – petrol	non	kJ/mth
		Construction machinery – diesel	non	kJ/mth
		Vehicles – petrol	Outdoor temperature	kJ/km
		Vehicles – diesel	Outdoor temperature	kJ/km
Urban heat system	Buildings	Heating and hot water	Outdoor temperature	kJ/m^3

tional structure. First, much of the information necessary to implement the EnMS was based on estimates which, for the entire company and all its divisions, resulted in significant discrepancies in detailed data.

For example, for buildings, the outdoor temperature and building volume are the primary variables that affect the amount of energy used for heating or air conditioning. The external temperature necessary to compare individual periods with the base energy determined in 2017, initially did not have an appropriate measurement methodology. Carrying out measurements in a different way between individual locations made it difficult to compare these branches. Different sources of information were also used for building volumes. Both of these things influenced not only the reduction of the credibility of the information obtained, but also made it difficult to correctly set energy targets, and the apparent increase in energy use in this area in the first year of the system operation.

Also, establishing and implementing the correct control and measurement plan for individual areas of the organizations functioning brings significant problems. In many cases, processes that are associated with significant costs in the organization's budget or are directly related to the main process being conducted, tend to be excessively indicated. In this case, for the main process related to the energy supply, there were originally 5 Energy Performance Index and several corresponding variables influencing the amount of energy consumption in this process. Ultimately, it was decided to use only two indicators – energy consumption in gaseous form and gas losses in process.

On the other hand, when selecting measures and creating measurement plans for auxiliary processes, there was a strong tendency to reduce the importance of these processes in the overall energy performance of the company. Especially in the areas related to office work, the maintenance of social departments and other elements commonly considered as not harmful to the environment, energy con-sumption was underestimated. Numerous problems with the correct metering and the collection of energy-related data in these areas during the implementation of EnMS were highlighted.

Data analysis after 1 year of operation of the EnMS

All indicators related to energy consumption monitored under the Energy Management System based on the ISO 50001:2018 standard were reviewed after one year for the functioning of the system in the organization. During the review also other data was checked. For example: energy consumption, the quality of data available in EnMS, the validity of the intensification of measurements and the degree to which goals related to increasing energy efficiency were met. Basic data describing the amounts of energy consumption in the main areas of the company's operation are described in Fig. 2.

Out of all analyzed areas of significant energy use, only the basic process related to the company's main activity was not underestimated. This is largely related to the significant share of the costs of this process in the entire budget of the enterprise. Moreover, for the process, an energy target was set, related to the gradual replacement of devices at service stations with more energy-saving ones.

In the analyzed period, in other areas of the Energy Management System, an increase in the absolute use of energy was observed. This indicates that without

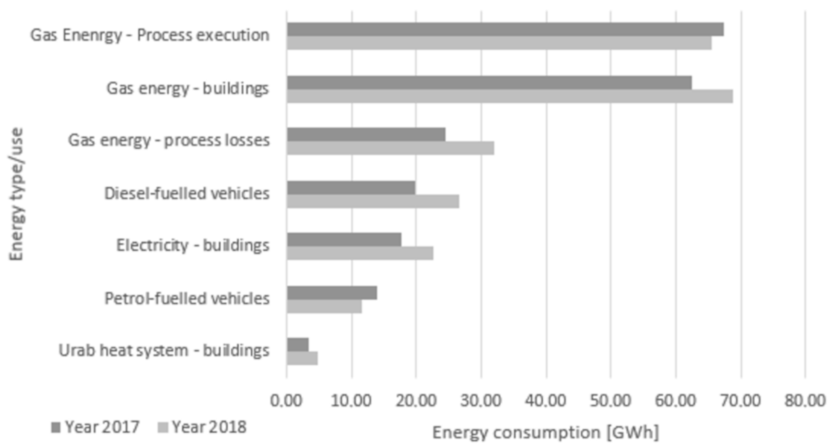

Fig. 2. Selected energy consumption in year 2017–2018 (own work)

EnMS, data on auxiliary processes such as building and water heating, fuel consumption in vehicles and losses are not calculated accurately. The introduction of the Energy Management System based on the ISO 50001:2018 standard made it possible to identify all places of energy consumption, which significantly influenced the picture of total consumption in the enterprise (Fig. 3).

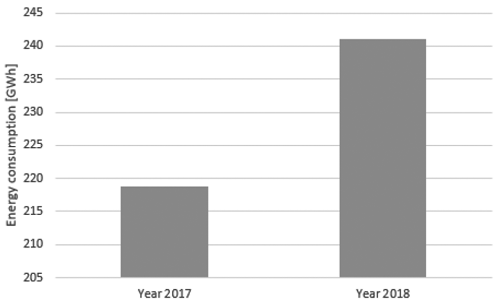

Fig. 3. Total energy consumption in years 2017 and 2018 (own work)

Despite the fact that the amount of energy consumption expressed in absolute numbers has significantly increased, which exceeded 11% of the total consumption, it should be noted that the individual Energy Performance Index indicators improved during the system operation in the enterprise. This is largely related to the effective selection of the values of variables for individual EPIs (Table 1), but also to the significant impact of activities undertaken to improve energy efficiency in the enterprise. The activities carried out include elements such as replacement of LED lighting, replacement of gas boilers with condensing boilers, purchase of company cars based on hybrid technologies.

For the basic organization process related to the services provided, the energy consumption in terms of EPI was reduced by 9.8%. This is mainly related to the replacement of the most energy-consuming devices in field stations with more modern devices, with better energy efficiency or, in some cases, based on renewable energy sources (photovoltaic panels in combination with wind turbines).

Considerable energy savings were also achieved in the area of electricity use in buildings. This is due first of all to a significant underestimation of the consumption itself in this area – the estimated absolute consumption was 28% lower than the actual consumption in the analyzed period. However, after the implementation of the EPI in the analyzed years, consumption turned out to be lower than in the year before the system was implemented. This is largely due to the low quality of information on consumption by the implementation of EnMS, and a significant improvement in the awareness of the organization's employees. One of the basic goals of the implemented system was to increase the awareness of how individual users influence the company's energy goals through the implementation of a training cycle. These trainings were carried out in all areas, with particular emphasis on the areas of significant energy use. The change in the values of individual Energy Performance Indexes is presented in Fig. 4.

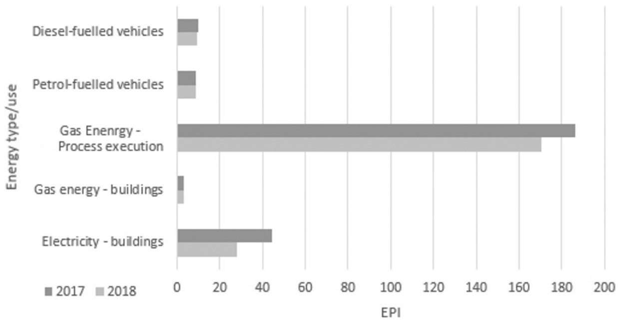

Fig. 4. Selected Energy Performance Indicators in year 2017–2018 (own work)

Conclusions and future work

Accurate and detailed collection of data on energy use in the enterprise is very important. In many cases the data on auxiliary processes are treated with less attention. It is also big and important problem for organizations with many branches and territorially dispersed buildings. Data related to main processes are, which is natural, meticulously collected in order to calculate the cost of manufacturing of a product, providing services or process efficiency. Reliable data collection on auxillary processes, as can be seen from the example described, is not so obvious. In the analyzed example, the energy consumption for the main processes is only 28% of the total energy consumption. In such a situation, a lax approach to auxiliary processes can lead to a significant underestimation of Energy Performance or incorrect determination of EPI and energy targets. In the analyzed case, in the first year of the system operation, such underestimation accounted for approximately 11% of the total energy consumption in the organization. Therefore, it is important that within the framework of the EnMS operation, all data on the various sources of energy use are collected with the appropriate accuracy. As shown in the article, energy consumption in auxiliary processes may constitute a significant share in the total energy consumption of the enterprise.

In further works, the data obtained from the next years of EnMS operation will be analyzed in detail. This will allow for a specific determination of the impact of information quality, EIP selection, as well as the impact of auxiliary processes on the functioning of both the system itself and the reduction of energy consumption in the organization.

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