

## Energy audit in feed production plant

Jacek Gembicki<sup>1,a</sup>

<sup>1</sup>*Szkoła Główna Gospodarstwa Wiejskiego w Warszawie Wydział Inżynierii Produkcji*

**Abstract.** The energy audit in a feed production plant is intended to specify its energy consumption and, if it is too high, propose changes aiming to reduce it. The energy audit may be internal or external, depending on whether it is carried out by trained workers of the plant or by an external company. The internal audit requires inconsiderable financial expenses but in effect does not assure a full picture of the energy consumption in the production plant. Internal audits may show disadvantages of the plant which the management board should pay special attention to. The external audit in turn provides a wider view of the plant and shows things unnoticed or skipped during the internal audit. The stages of the audit have been specified in relevant rules of law. The results of the audit and their implementation do not need to require considerable financial expenses, but may instead lead to substantial savings, thanks to which the production is more profitable and the plant more competitive on the market

What is the Energy Audit and what is its purpose? To answer the question, let's refer to the definition of the Energy Audit, which will also be the basis for scrutinizing the subject. The energy audit is an elaboration that specifies the scope, technical and economic parameters of the project, as well as indicates the optimal solution from the point of view of costs in this respect. The audit also serves as a useful elaboration for the system user (entrepreneur) and a basis for gaining the right to thermo-modernization bonus. It is also an assumption for the building permit design related to the project in question.

The legal basis for the Energy Audit and its completion is included in the following documents:

- Resolution of the Minister of Infrastructure of 17 March 2009 (on a detailed scope and forms of energy audits, templates of audit charters, as well as algorithm of assessing profitability of the thermo-modernization project)
- Act on supporting thermo-modernization and renovations of 21 November 2008
- Polish construction standards
- Resolution of the Minister of Infrastructure of 6 November 2008 (on methods of calculating energy performance of buildings and residential accommodations or part of the building being an independent technical and functional entity, as well as a method of preparing and templates of certificates of their energy performance).

The factors determining energy consumption also have an impact on the energy audit. Certain factors have a considerable influence on the entire plant and it is difficult to change them, whereas others can be easily modified [1].

Much depends on whether a given plant has enough funds to introduce new technologies.

- Productive capacities utilization factor,
- Production profile (range of products),
- Proper selection of performance characteristics of devices and energy carriers,
- Device work system (permanent, periodical),
- Degree of mechanization and automation of processes and production operations,
- Proper selection of engines and installed power structure,
- Machine operation and maintenance system
- Quality of materials,
- Spatial development and cubic volume of rooms,
- Material delivery schedule and production organization,
- Efficiency of energy use inspection and ability to draw proper conclusions.

As far as the energy audit is concerned, it is advisable to make reference to energy certificates and answer the following questions: what is it and what is it for? The questions listed below will be of assistance as well.

What is the energy performance certificate? The document prepared and certified by the authorized specialist that specifies the amount of energy consumed for the purposes of heating, preparing hot water, ventilating and air conditioning the building/accommodation. The energy consumption index (E) is expressed in kWh/(m<sup>2</sup>year), and specifies the amount of energy consumed throughout the year per square meter. Depending on its value, the certificate assigns one of seven energy classes (A-G rated) to the building/accommodation.

<sup>a</sup> Corresponding author: gembicki.jacek@gmail.com

Who is responsible for preparing the energy performance certificate? The owner of the building/accommodation is obligated to prepare the certificate. The certificate should be provided to the purchaser or tenant/renter of the building. With regard to new buildings which are handed over, the energy performance certificate is a document required to gain occupancy permit, whereas in the case of selling the building/accommodation, it is necessary to sign the notarial deed.

What are the benefits of preparing the energy performance certificate? The energy class assigned by the certificate specifies the energy quality of the building/accommodation, and therefore its attractiveness in terms of sale or rental. Additionally, the certificate defines the guidelines and recommendations related to potential improvements to be made by the owner in order to reduce the energy demand. Thanks to the certificate, purchasers or renters/tenants are able to estimate power consumption costs related to the use of the building/accommodation and choose the offer that suits their financial situation.

Now we know what the energy audit and energy performance certificates are. Let's see how to carry out a basic energy audit.

1. Preparing checklists.

Before the energy auto-audit is carried out, it is obligatory to collect and organize data related to the production plant. For this purpose, it is necessary to prepare the so-called checklists which specify the list of recommendations, checks, measurements and analyses relevant to plant assessment. We can distinguish 14 groups of factors. Each of them describes detailed recommendations with regard to measurement, data collection and their analysis [2].

2. Preparing a device operation schedule within a day (working day photograph) and analyzing a load duration curve.

We prepare a list of intended uses with regard to devices in the product plant and then develop a method of using these devices in order to eliminate downtimes and ineffective use of machines.

**Table 1.** 14 groups of factors use in Preparing checklists

Item	Factors	Detailed description
1.	Spatial development, production facilities	Location, location in terms of a part of the world, dimensions, cubic volume, shape, building age, building surface and cubic volume use factor.
2.	Primary energy	Place of storage, consumption, primary source of energy costs, possibility of changing deliveries and energy carrier suppliers.

3.	Electric energy	Power supply and maximum load, transformer's condition, possibility of correcting peak power, possibility of using alternative rates.
4.	Energy conversions	Type, model, age of boilers and burners, quality of burning, watt-hour efficiency; consumption of fuels by each device.
5.	Cool management – cooling devices	Equipment, type, class and age of compressors; operation and use conditions; efficiency of cooling devices.
6.	Energy distribution	Leakage and losses in distribution of hot water, water steam and heated liquids; leakage and losses in the cooled water distribution system.
7.	Room heating	Type of heating system; heating device operation schedule with reference to real use of the facility; adjustment of room temperature to production technology requirements and operation conditions.
8.	Air conditioning and ventilation	Operating conditions of air conditioners and ventilating devices with reference to facility use.
9.	Domestic hot water	Condition and capacity of storage water heaters; feed water parameters.
10.	Heating and cooling processes	Degree of adapting real parameters to project-related conditions.
11.	Lighting	Type of lighting; measurements of luminous flux; conditions, settings, activation of existing lighting fittings.
12.	Compressed air	Installed power, age and degree of wear of air compressors; equipment condition; use and operation conditions.

13.	Waste energy	Possibility of recovering heat from products, post-production waters.
14.	Machine use and operation	Friction wear, lubricating.

3. Establishment of permissible loads (limits) and explanation of reasons for exceeded values.

We set real and planned use of machines, we check the power intended for them, and attempt to optimize their operation to assure effective and economical use.

The devices which are to be switched off at peak hours must be equipped with information boards which specify the shutdown hour.

In the event of exceeding the power limit, the user (entrepreneur) is obligated to cover expenses arising from the rate set out in the agreement with an energy provider.

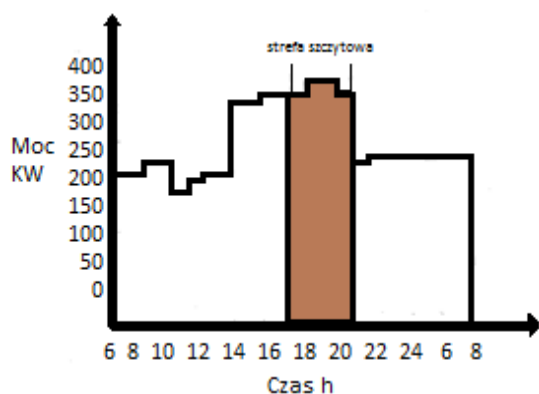


Figure 1. Use of electric energy before improvements

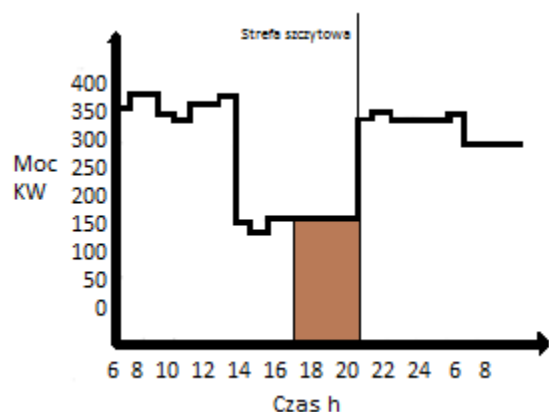


Figure 2. Use of electric energy after improvements

4. A detailed analysis of heat energy receivers that includes water heater or steam boiler efficiency. When carrying out the energy audit, it is obligatory to inspect other energy load points (energy receivers) which may affect the audit of the entire plant.

The example presented below shows what we can achieve by using the energy audit.

When we use technical solutions, we aim to create such conditions in which electric energy is somehow accumulated in the form of work performed. There is a number of usage possibilities in production processes. When the production cycle is complex, then by storing part

of the work at one of the stages (where electric energy serves as a source), we achieve the same effect as if the electric energy was stored. [3]

Referring to organization-related projects, we may state that it is possible to modify operation of not only receivers that work for part of the day but also those which operate permanently but are not fully loaded behind peak hours. The quantitative production drop is used by increased machine load and increase in their efficiency during other hours of operation. [4]

For instance, if the production line operates for 3 shifts at the average efficiency of 82%, maximum hour efficiency

$A_{hmax}$  then its day output is

$$A_{dob} = 24 \times 0,820 \times A_{hmax} = 19,68 A_{hmax} \quad (1)$$

This output will not decrease if it is suspended for three peak hours, and during other 21 hours will operate with the efficiency of  $0,937 A_{hmax}$

$$A'_{dob} = (24 - 3) \times 0,937 A_{hmax} = 19,68 A_{hmax} \quad (2)$$

When we stop the line in question even for 4,3 hours during peak hours and resume operation in the remaining period at full load, we will be able to achieve output volume in accordance with the following:

$$A''_{dob} = (24 - 4,3) \times A_{hmax} = 19,70 A_{hmax} \quad (3)$$

It sometimes happens that a receiver faces time-related challenges, and it is not only its insufficient efficiency but also a need to maintain continuous work of particular links of the entire production chain. In these conditions a proper solution is the use of equalizing tanks suitable to a given production factor. These tanks should have such capacity that despite shutdown of particular elements of production line devices it is possible to assure continuous work of the entire cycle. It applies to e.g. tanks for disintegrated material which when accumulated allows suspending the work of grinders for a specific period of time. It also applies to liquid material tanks or liquid half-finished product tanks which allow suspending pumps at peak hours. The use of equalizing tanks and containers allows a vast array of adaptations of these solutions, and thus energy savings. [5]

Positive effects of the energy audit:

- Increased efficiency at non-peak hours leads to equalization of load curve in the power system (effect in macro scale),
  - Reduced energy consumption of the national economy (macro scale) and decreased CO<sub>2</sub> emission and other atmosphere pollution,
  - Reduced impact of energy costs in production expenses
- To recapitulate, audits and building energy performance certificates should base on guidelines and the algorithm stipulated in the legal regulations and standards. This is the requirement to assure that the documents are useful and applied when planning and carrying out the investment intended to reduce the energy consumption in

the production plant. A reliable preparation of such documents is possible if the contractor cooperates closely with the manager or owner of the production facility. In turn, the certificate is a required document when a given building is to be handed over (commissioned), sold or rented. Such audit may entail new investments in the production plant, yet with time these investments may lead to substantial savings and increased competitiveness of the facility.

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