ENERGY AUDIT METHOD FOR INDUSTRIAL PLANTS

Karlis Grinbergs, Bc. Sc Ing.
Energy Case
E-mail: grinbergs.karlis@gmail.com
Sandra Gusta, assist. prof., Dr. oec.
Latvia University of Agriculture, Faculty of Rural Engineers, Department of Architecture and Building
E-mail: sandra.gusta@llu.lv

ABSTRACT

Different studies have shown that there are opportunities for major energy efficiency improvements in the industrial sector and many of them are cost effective. These energy conservation measures are general and also niche specific.
Owners or managers of industrial parks and factories are not always aware of the possibilities for energy efficiency improvements. Energy audit is the first step in order to discover the possibilities of energy savings, prioritizing projects, tracking progress and making system adjustments after investments.
Industrial energy audit is a process that makes saving of energy and raw materials possible. Quality of the end product often is also increased. By improving a local electricity grid and overall building and manufacturing process characteristics there is also often observed a decrease in factory down time.
Industrial energy audit is quite new in Latvia, but by using the world experience and following standards, projects have been elaborated where the energy savings exceed 70% of total energy demand (Latvijas…, 2011). These processes have defined the topicality of this article; the aim of the article is to analyze energy audit method for industrial plants.

Keywords: industrial energy audit, energy efficiency, energy savings, industrial energy audit guidelines

INTRODUCTION

Global competition, carbon emission regulations and integration in the European electricity market will most probability increase the demand for energy efficiency on the part of companies all over Europe.
Conducting an energy audit is one of the first steps that must be done in order to identify the possible energy efficiency positions. Even by knowing the exact procedure of the industrial energy audit many plants do not have the capacity to conduct an effective energy audit without any external help. The existing regulations for industrial energy audits are only descriptive and do not provide any specific action plan or process description; the audits conducted by professional certified energy auditors are unique and hardly comparable. But usually manufacturing companies lack the knowledge about the possibilities of energy savings and increased productivity. And because of the lack of quality information only limited technical and financial resources for improving energy efficiency are available, especially for small and medium-sized companies. Information in industrial energy auditing and energy efficiency practices should be prepared and distributed to industrial plants and other related companies (National…, 2005).

STEPS OF INDUSTRIAL ENERGY AUDIT

An industrial energy audit is a process that facilities energy usage patterns, equipment efficiency, and overall building efficiency is determined in order to propose energy efficiency measures. The result of a successful energy audit is decreased energy consumption, reduced raw material usage and increased quality of the end product. The data collected by an energy auditor is the basis on which the energy efficiency suggestions will be created. The implementation of these measures will reduce manufacturing costs and also the negative effects on the environment. "Industrial energy audit is a new term in Latvian. It is a process aimed at finding loopholes in the production process, a design task in order to save raw materials and energy. Performing industrial energy audits makes it possible to save raw materials, energy, optimizing the manufacturing process or raising the company's profits and increase competitiveness. After an industrial energy audit, the client data will have an accurate list of energy efficiency measures which will reduce costs and the environmental impact. The industrial energy audit consists of the following steps (International…, 2007)" (see Figure 1):

Step 1. Data collection:

- The presentation of the process or stage. The first task of the energy audit is getting acquainted with the entire production process or stage. What is produced, which inputs are used?

How much water is supplied, the amount of energy used, characteristics and quantity of raw materials used and other specific information that can be useful in the audit process, for example waste treatment.

- The principal scheme. When gathering data for the energy audit the principal scheme can be very useful because it includes all of the energy flows and process relationships.
- Data collection. Collection of data on the entire production process and a specific period is one of the main steps of the energy audit. When collecting data about the manufacturing process and systems, it is very important to collaborate with the employees as they know the systems very well.
- The benchmark. The collected data are compared with the data from similar companies across Europe or Latvia.
- Defining the problem. After comparison of the consumption problematic systems, systems with relatively high energy usage can be defined.

Step 2 Data processing:

- Creating a team of specialists. After defining the problem, the specialists from the appropriate fields are incorporated into the audit process.
- Necessary calculations. Calculations are carried out for all of the manufacturing steps, and the possible energy efficiency improvements are identified.
- Accurate scheme for the production of energy and raw material flows. A pre-established production scheme is improved, supplemented with information acquired in the energy audit process

Step 3 Analysis of results:

- The most appropriate solutions are identified and justified.
- Exact energy efficiency suggestions are presented. The goal of the suggestions is improving the manufacturing process and decreasing energy and raw material consumption.
- All of the suggested improvements are integrated in an overall process diagram or scheme in order to obtain a better understanding on how these changes will affect the overall manufacturing process.
- Selection of an appropriate solution based on the potential savings, the impact on production processes and technologies, as well as potential investments are selected for energy efficiency measures to be economically justified.

Step 4 Recommendations for improvement:

- Proposed technology integration in the scheme. Improvements are included in the scheme in a way to better understand how it will affect the entire process.
- The choice of the right solution . Based upon the potential savings, the impact on production processes and technologies, as well as potential investments and ROI, energy efficiency measures are selected.

Step 5 Economic foundations:

- All of the energy efficiency suggestions are justified for their economic benefit. Measures considered most often: pay-back time and ability to attract EU structural funds.
- Choosing economically reasonable energy efficiency measures. After an economical analysis, the most advantageous measures are chosen. Pay off times and capital costs are considered.(International…, 2007)

ANALYSIS

The main purpose of an energy audit is to find out the energy usage patterns, the amount of energy used, and most important - the amount of energy needed. Next, based on these findings the auditor must develop possible scenarios of energy efficiency with precise recommendations and return on the investment analysis. In Figure 1, the general energy flow is shown, two main parts are considered – total facility energy use and facility energy production (National…, 2010). Often the only measured branch from the facility energy production chart is thermal energy production, but even more often this energy is used in a non-efficient way. A different situation is in the "Total Facility Energy
Use" branch, because the energy consumed by the facility is precisely metered due to the fact that this is the metric by which the facility is billed by the energy supply company. But if the energy is used in different processes and facilities, the need for local energy monitoring devices arises. Detailed energy consumption monitoring provides the information necessary for adjusting the manufacturing process in order to obtain higher energy efficiency and lower energy costs even without changing any equipment. This information can also be used to determine the main energy consumers and create an action plan to lower the overall facility energy usage (Canadian…, 2010). Tier 1 layer in Figure 2 accounts for facility energy production and facility energy usage. The total facility energy usage can be either positive or negative depending on the facility type and equipment used. Most of the time the net facility energy use will be negative, because the majority of the companies are only energy consumers and not producers. This is especially true in Latvia; most of the companies lack the capabilities of energy production either for themselves or for selling to the grid. Often this is due to the fact that there are no additional resources to spend on new, energy producing systems and most commonly due to the difficulties of selling energy back to the grid (International…, 2007).

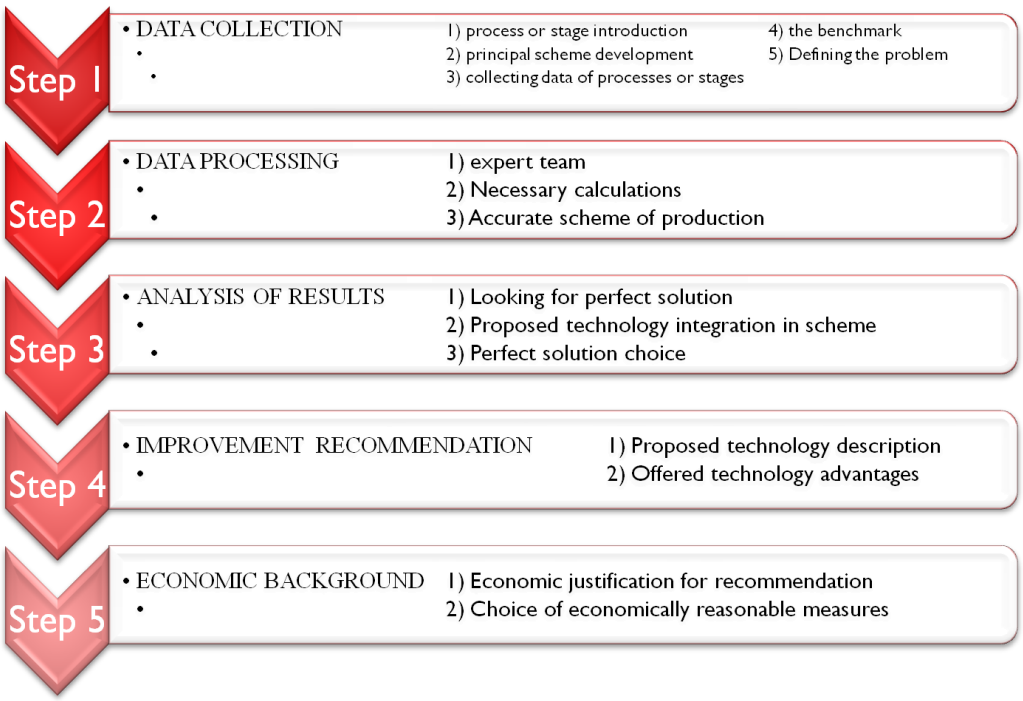

Figure 1. Steps of industrial energy audit (Gusta, 2012)

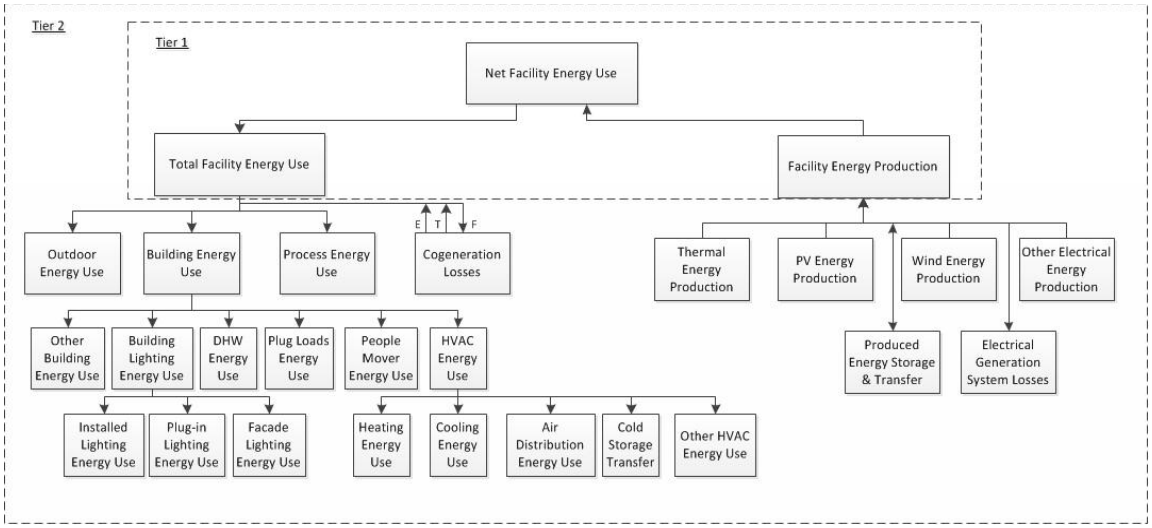

Figure 2. Net facility energy use

Tier 2 in Figure 1 provides a closer look at energy consumption and production systems. This allows the energy auditor to analyze the energy consumption patterns and suggest possible energy efficiency measures. The most energy efficiency measures are taken for overall building energy use, including energy for heating, ventilating, air conditioning, indoor lighting, facade lighting, domestic hot water, plug loads, people andproduction movers, other building energy use and also process energy use (National…, 2005). When a building is multifunctional, the energy use may be determined to each functional area for the comparison with other building areas of the same type.

In the industrial sector often the most energy consuming position is the “Process Energy Use”. Process energy use is the energy consumed in a building or elsewhere at a facility to support a manufacturing, industrial or commercial process other than conditioning and maintaining comfort for the occupants. Examples include an electrical welder, machine tools, steel melting furnace, wood drying chamber and other high power appliances. In

an office environment, typical personal computers are not categorized as process loads; nor are servers that support building operations. However, server computers at an Internet service provider company are process loads. Process energy use does not include the effect of this energy use on heating, ventilation and air conditioning loads. Any heat recovered and used at the facility in a way that offsets the consumption of purchased energy or other energy generated at the facility is subtracted from process energy use and included in the metric that corresponds to the energy use (European…, 2012). The flow diagram in Figure 3 illustrates the relationship between the energy usage and energy production in a facility, the diagram accounts for the majority of possible energy usage or production capabilities.

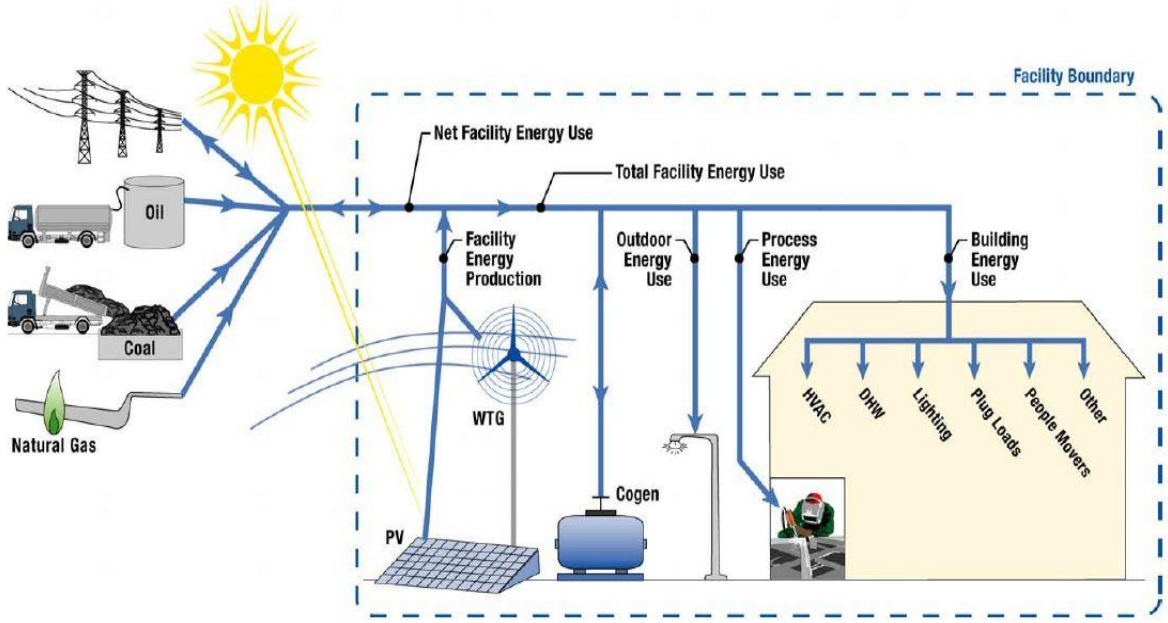

Figure 3. Energy flow diagram providing an illustrative view of energy consumption and production (National…, 2005)

Gathering data through an array of different methods such as measurements, bill analysis and other available sources, is one of the main activities of energy auditing. Without accurate data the energy audit cannot be successfully accomplished. A lot of data are readily available and can be collected from different divisions of the plant that is being audited. But some data require precise and detailed measurements, often over a period of time. The energy audit team is usually well-equipped with all of the necessary measuring instruments (European…, 2012). The most common energy types measured during the auditing process are:

- Liquid and gas fuel flows.
- Electrical measurements (voltage, current, load diagrams, power and power factor).
- Temperatures of solid and liquid surfaces, including surface thermography.
- Building infiltration and exfiltration parameters.
- Pressure of fluids in pipes, furnaces or vessels.
- Fume gas parameters (CO_2, CO, O_2 and PM).
- Relative humidity.
- Luminance levels.

All of the acquired data must be carefully processed and interpreted in order to obtain the most accurate result possible (United…, 2009).

Benchmarking is a very important step in order to acquire plausible energy efficiency expectations. Although in Latvia there is no database where to compare the findings. The most common benchmarking unit for industrial plants is energy usage per one unit of production. Also it is common to compare types of energy used in common industries or energy used per activity as seen in Figure 3.

The main advantage of an energy balance diagram is that all energy inputs can be quantified and balanced against all energy outputs. The most convenient graphical representation of this is the Sankey diagram. In the Sankey diagram, the energy losses/outflows, the energy gains/inflows, as well as the usable energy in a given energy system are represented quantitatively and in proportion to the total energy inflow, according to the existing data from energy bills and invoices, calculations and on-site measurements in the plant. Presenting the energy flows in a visually appealing way with the aid of the Sankey diagram helps to locate the most critical energy-consuming areas of the energy system and, at the same time, to identify the sources that lead to energy losses. Figure 3 provides an example of the Sankey diagram with energy flow patterns (Ernest…, 2010).

Improvement of energy efficiency is the most important step towards the three goals of the energy policy: security of supply, environmental protection and economic growth. Nearly all of the global energy demand and CO_2 emissions are attributable to manufacturing, especially in the large primary material industries such as chemicals and petrochemicals, iron and steel, cement, paper and aluminum. Understanding how this energy is used and distributed is a national and international responsibility; and the potential for efficiency gains is crucial for decreasing CO_2 emissions. In Latvia the industrial audit idea is new and there have been only a few audits conducted, but the trend is clear, there is a great saving potential in the Latvian industrial sector (Kursiša, Gleizde, 2013). The main investments in industrial energy efficiency in Latvia cover renovation of the building envelope, improvement of inner heat supply, ventilation systems, hot water systems, lighting system and mainly improvements in the technological process itself.

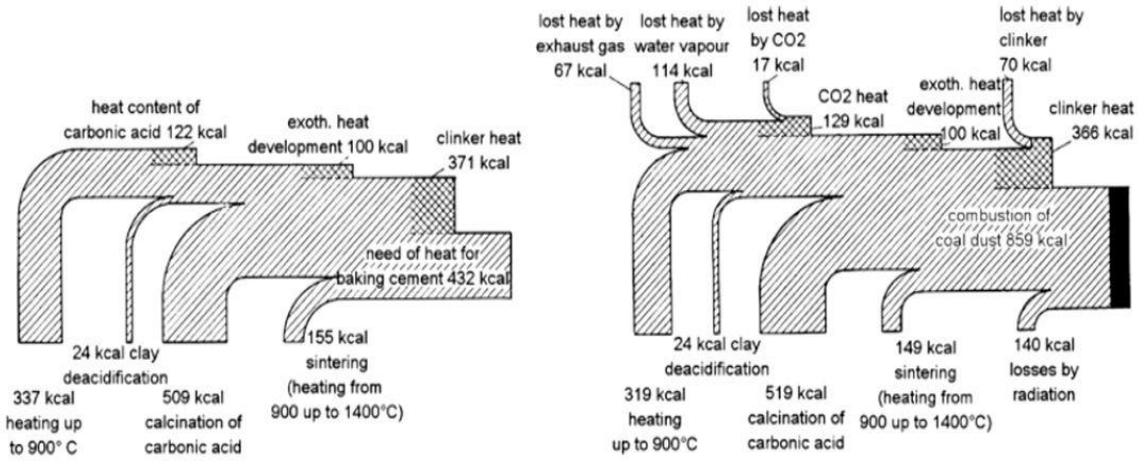

Figure 4. Sankey diagram shows the theoretical heat outlay (left) and practical heat consumption (right) in cement production (Ernest…, 2010)

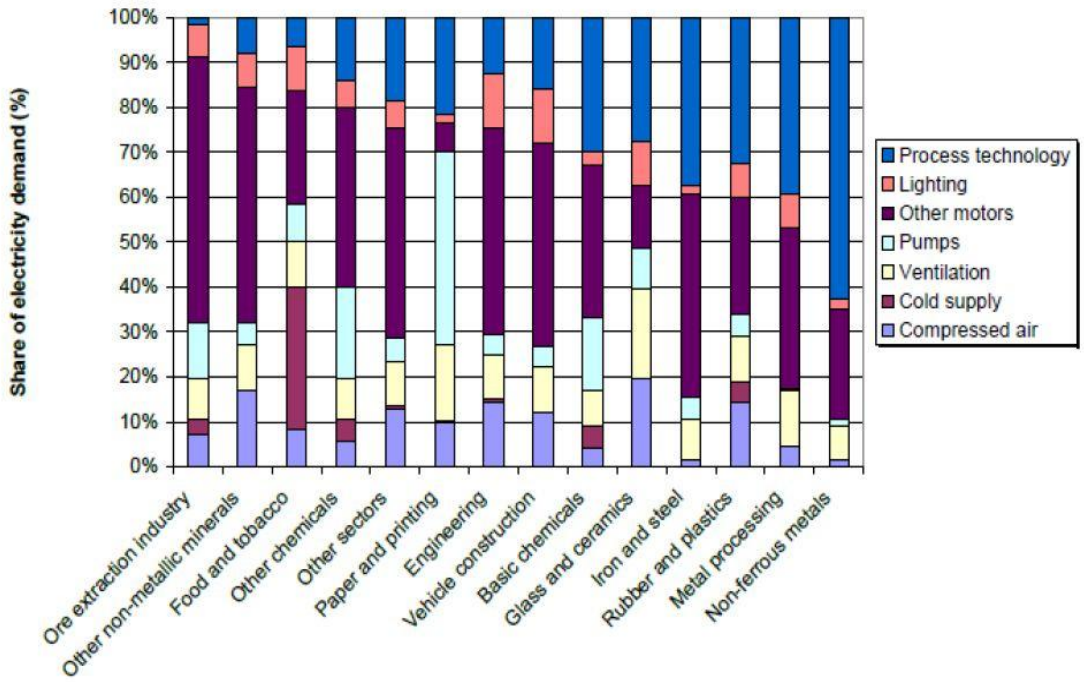

Figure 5. Share of electricity demand by application (European…, 2012)

CONCLUSIONS

1. Energy efficiency is one of the most important and most cost effective tools that can be applied for any facility. The goal of energy efficiency is to reduce the amount of energy required to provide products and services, or a healthy indoor climate.
2. Although world wide the industrial energy audit is a common practice, in Latvia it is something new and yet to be applied for most companies and facilities.
3. Improving facility energy efficiency gives the possibility to decrease CO_2 emissions and overall fuel consumption. The decrease of fuel consumption often is the main goal of an energy efficiency program.
4. There is a lack of knowledge about energy efficiency and what it has to offer. The concept of energy audits usually is understood only as a process of accessing energy flow for residential buildings, not factories, office buildings or similar industrial facilities.
5. In order to increase energy efficiency the need for additional energy monitoring devices are recommended. Monitoring devices should be installed for every big energy consumer or at least for every facility in order to be able to monitor energy usage and the usage patterns.

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