A method for bottom-up energy end-use data collection – results and experience

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Abstract

Improved industrial energy efficiency is one of the most important means of reducing the threat of increased global warming. However, one of the major challenges today related to improved energy efficiency in industry is the lack of well-structured bottom-up data for various sectors. The aim of this paper is to present a structured method on the collection of industrial bottom-up data, and unique results from a case study of the Swedish foundry industry, as well as other industries, where the method has been applied. Results show that the method is useful in receiving unique energy-end-use data for the industry, and shows that the energy end-use for similar companies in regard to different process-specific energy users can be very large. Results also show how different energy end-users can be categorized and thus benchmarked in a structured way. A part of this study was done within the Intelligent Energy Europe project Foundrybench, with the effort to develop a guideline on how an energy audit may be carried out in the foundry industry, and to develop industry-specific key performance indicators.

Introduction

The threat of increased warning is pushing states and industries to work with deploying carbon reducing actions. Improved energy efficiency is one of the most important means for carbon reducing actions (IPCC, 2007). Improved energy efficiency can be achieved in a number of different ways such as technology improvement, and improvement in the operation of equipment. The use of indicators can greatly facilitate the process of improving energy efficiency as a normalized level of energy use can be detected and later be used to set targets for improvement. The use of indicators is widely used in the economic discourse, e.g. Mossberg (1977), Martínez and Silveira (2012).

A few papers have also been published using energy indicators, e.g. Eichhammer (2004), and on sectoral level see Worrell (2013). The benchmarking of energy data has been facilitated by the new European standard EN 16231:2012. However, the standard does not provide actual data nor a method for how to collect the data, particularly for various sectors. Moreover, while benchmarking figures for certain types of buildings are comparable and exist today; the use of bottom-up indicators for industry is far more complex and process-specific. Furthermore, comparable bottom-up energy end-use data is scarce, or put differently; the data exists but there is no uniform way of collecting or structuring the data, thus leaving the value of the data for external actors outside the company (researchers, sector organizations, national energy agencies) less useful. One of the major challenges today related to improved energy efficiency in the industry is thus the lack of well-structured bottom-up data for various sectors as well as a methodology on how to collect and structure this data.

The EU-funded IEE-project Foundry Bench was carried out during 2009-2012 with the explicit aim of creating a harmonized way of collecting the data, and creating a structured way to collect and treat the data from the foundry industry. In addition to this, the Swedish project ENIG (Energy Network In Group) has been developed using bottom-up energy indicators reported by various industrial companies in general, and Swedish manufacturing companies in particular. The aim of this paper is to present a structured method on the collection of industrial bottom-up data, which includes using unique results from a case study of the Swedish foundry industry, as well as from other sectors where the method has been applied. The paper is a result of the Swedish ENIG-project as well as the EU-funded IEE project Foundry Bench.

Gaining benchmarking of data step by step

The Unit Process-approach

The support process-specific data can be gained through a normal energy audit using for example the European energy audit standard (EN 16 247-1). The collection of data can normally be done by any auditor having general knowledge of the support processes. However, for the production-specific processes, knowledge of the processes is of key importance to gain the maximum potential of a data collection conducted in e.g. an energy audit. This importance stands in direct relation to the energy-intensity of the company, i.e. a company with large energy use in the production processes, may miss out on the benefits if an energy auditor not being aware of the function of the core business in the company. This process-specific knowledge is often lacking among auditors, and therefore the value of the audit may be less useful for the companies in question. The first part of an audit is the setting up of an energy balance. Using the unit process categorization, a general way of structuring data is gained. The unit process categorization divides the energy use of an industry into smaller parts, also referred to as units. A unit process is based on the purpose of a given industrial process, e.g. cooling or drying products, mixing material, producing compressed air, carrying goods etc. Unit processes may be considered the smallest parts of an industrial production system and its related energy use. The unit processes are thus general across all companies, which allow process-specific comparisons between industrial companies with regards to e.g. energy efficiency. The process is divided into two major parts:

- production processes – the processes needed to produce products
- support processes – the processes needed to support the production processes, but not directly needed for production.

Based on Söderström (1994), the eleven production processes and the ten support processes are presented as below in Table 1:

Table 1- Structure of unit processes categorization according to Nord-Ågren (2002) and Söderström (1994), and further developed in Thollander et al (2012).

Production process	Disintegrating	Support process	Ventilation
	Disjointing		Space heating
	Mixing		Compressed air
	Jointing		Lighting
	Coating		Pumping
	Moulding		Tap water heating
	Heating		Internal transport
	Melting		Cooling
	Drying		Steam
	Cooling/freezing		Administration
	Packing		

The KPI-approach

The company's KPI (Key Performance Indicators) are divided in three different levels.

- Overall figures such as MWh/ton, kWh/m^2, MWh/turnover, etc.
- Support process-specific figures such as ventilation, compressed air and lighting
- Production process-specific figures such as melting, moulding etc.

The overall data can normally be collected without any additional measurements at the company. However, before the benchmarking process begins, it is important to agree on common definitions such as turnover before or after taxes, primary energy or energy end-use data etc. Without a real energy balance of where energy is used in a company, (i.e. which are the most critical energy end-users), the task of improving energy efficiency in a company would be much more complicated and speculative or to use an allegory; a controller cannot set up a sound budget if previous year's data of cash flow is missing. Similarly, the same holds for energy management controlling.

The unit process categorization for the support processes is not suitable for the individual company, audit or sector organization in defining their specific production-specific processes. Thus, the following section presents a method for how to achieve such relevant production-specific benchmarking data, exemplified by a sand-mould foundry.

Step 1

The various industrial processes initially need to be categorized. For a sand-mould foundry, the major primary industrial processes are presented in figure 1.

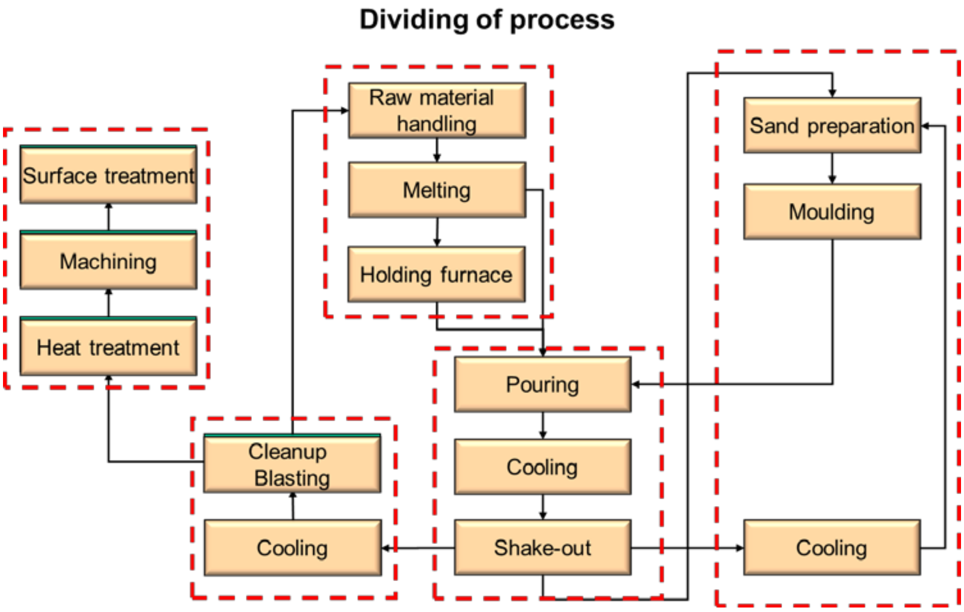

Figure 1- Division of processes in sand-mould foundry

Before the energy audit is performed, it is advisable to divide the process into production areas. In a sand-mould foundry a suitable approach could be that presented in figure 1 above. The reason for the division in this way is that all the parts are not available on all foundries and can then easily excluded when you want to compare the process with other foundries. The division may also be appropriate in case you want to follow a single product through the process. The production of various products in a foundry might not go through the whole process or it could be that they are produced with a different technique.

Step 2

When the division is completed, the energy audit can be performed and an energy balance is created across both support and production processes. The project Foundrybench developed an energy-mapping method for the foundry industry that can be used for energy audits in the foundry industry (Tapola, Hagner & Hihnala, 2010)

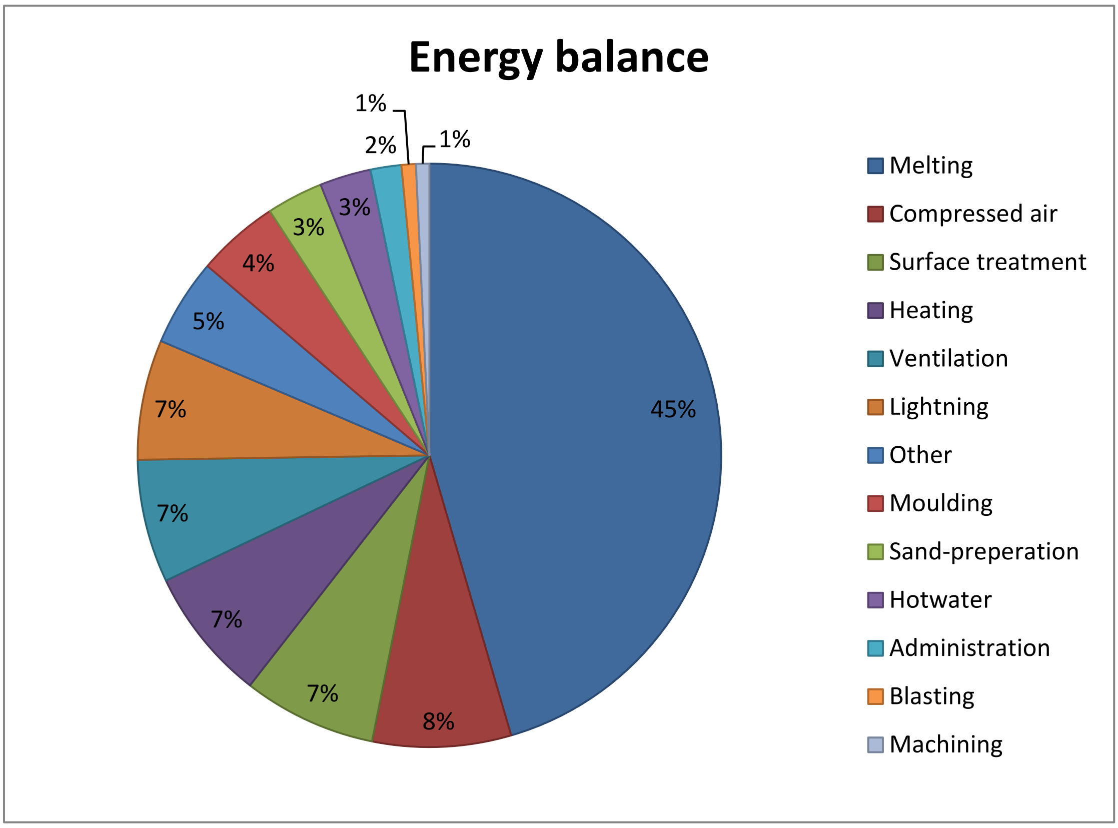

Figure 2 - Presents results from a typical energy audit in the Swedish foundry industry

Step 3

In order to create relevant KPIs for the production processes one need to understand the basics of KPIs and what relevance each KPI gives. KPIs can be explained as compressed information and in this case, it would represent energy use in the enterprise. Since the KPIs are a condensed form of information, it is important to know the values that form the basis for the key indicator. It is also of importance to know the relationship between different indicators. For instance, financial ratios usage can be different depending on what needs one has, but the main use of such a KPI would be as a support in the decision making process for investments and to monitor energy-efficiency measures. But the question remains what is a relevant KPI? This depends greatly on the situational context and who the user of the KPI is. For example, for the company's management, overall indicators are most relevant. On the other hand, if you work in a foundry smelter, molten energy indicators are more interesting. If one looks at the breakdown of the foundry process, it is natural that there are various ratios that are of interest, depending on the process section you work in. In order to build an indicators structure, this needs to take into account the big picture. For a foundry and also in other industries, it may be appropriate to ensure the amount of energy used compared to the production. By utilizing and combining energy and production figures, one would get two ways of improving the indicator - by focusing on improving the production efficiency on the one hand and on the other hand improving the energy efficiency, or both. It´s important to have several KPIs and the knowledge of how they relate to each other in order to see which parameters that have changed. More of how to use KPIs is presented under step 4.

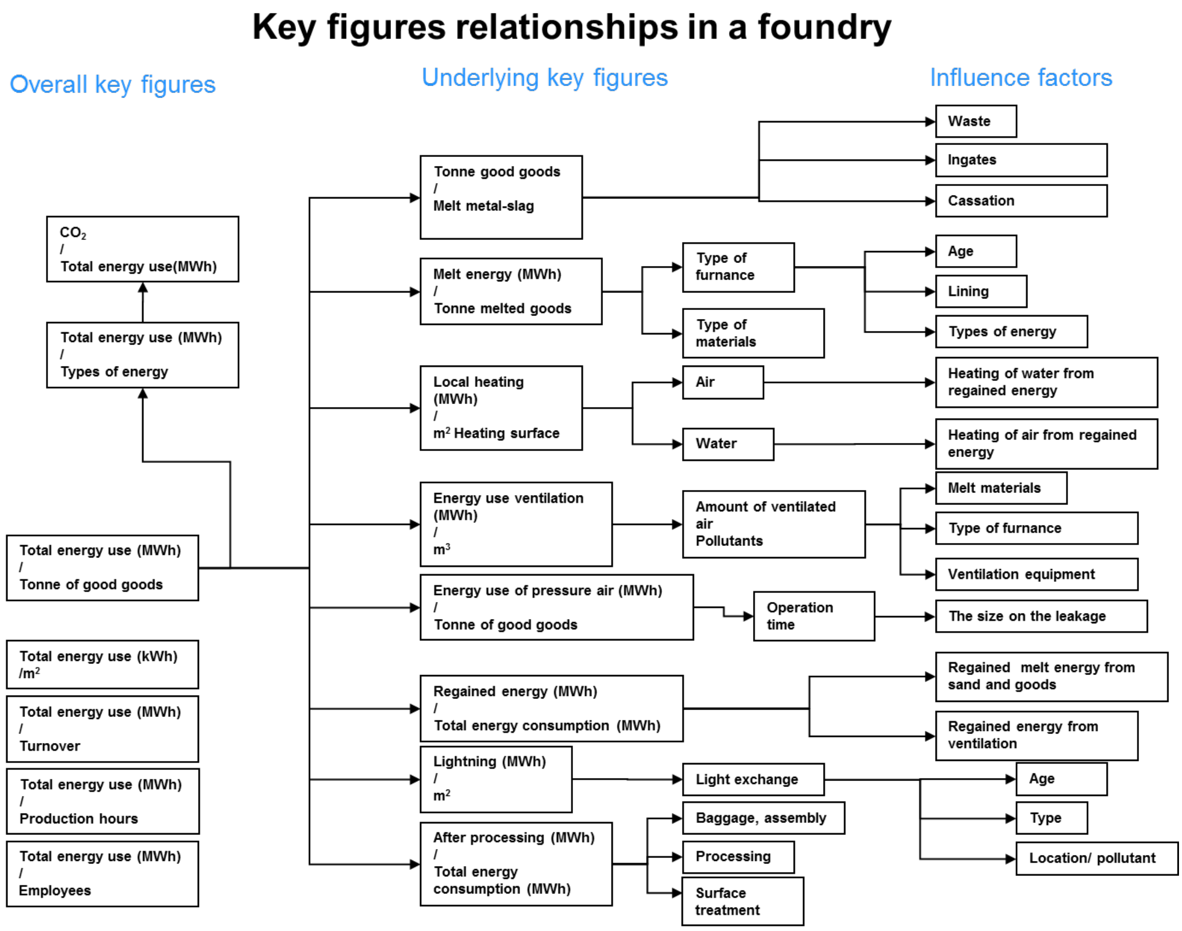

Figure 3- Above is an example on how energy relevant KPIs are related to each other in a sand-mould foundry.

Step 4

Key figures can be used within the organization at different levels and they can also be used when one wants to compare and benchmark themselves with others. Key indicators may also be useful in comparisons and improvements on both system level and component level. When it comes to investments, key figures can be appropriate to use in order to make the right demands towards suppliers, for instance. Using key figures requires that there are other key figures that can be related. For example, MWh / ton is a key figure which is composed of two values that change continuously. In order to know if there is a change in energy or production, so the comparison can be made with such kWh/m2 where the value m2 is a relatively constant factor. If the latter value is stable it would consequently mean production has changed. In order to make accurate estimates there is a learning process that one needs to take into account and go through in order to understand what is reasonable. Help with analysis can be obtained by experienced energy Surveyors with knowledge of the process.

In addition, the metal yield is a major factor affecting the above processes' energy use but not a process that can be used to structure the data collection. The material yield affects both sides of the key figure MWh / ton, so to work continuously to increase the yield is a great way to get better energy utilization. In general a better control of this ratio would be good for the profitability of many industries and the ratio could also be improved via an implementation of Lean for instance.

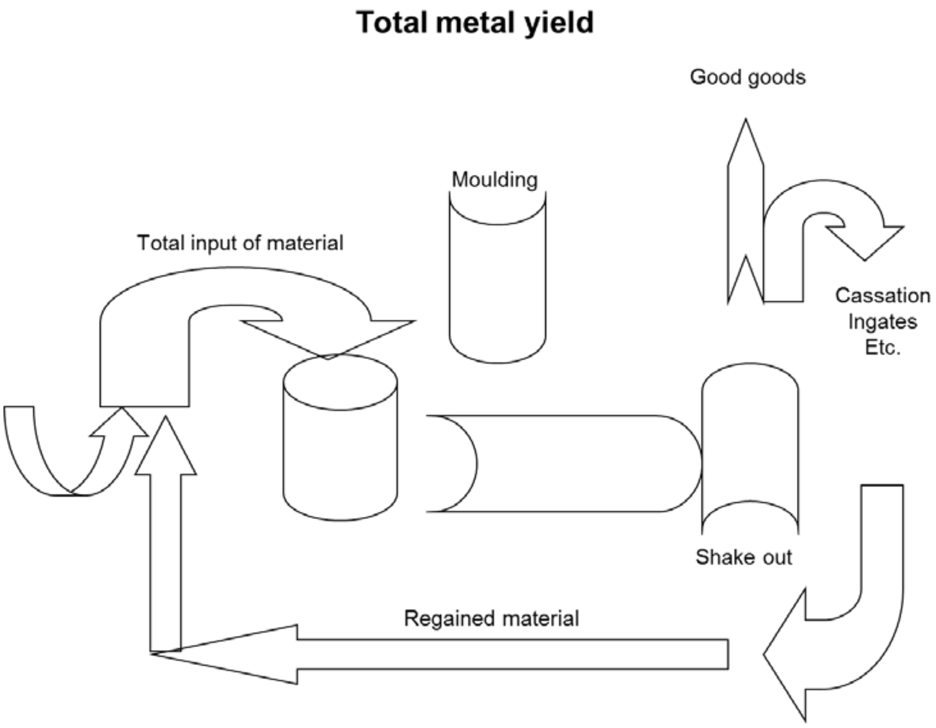

Figure 4 - Description of the flow of metal in a foundry.

Concluding discussion

Results show that the method is useful in receiving unique energy-end-use data for the industry, and shows that the energy end-use for similar companies in regard to different process-specific energy users can be very large. Results also show how different energy end-users can be categorized and thus benchmarked in a structured way. The study was a part of the project Foundrybench, with the effort to develop a guideline on how an energy audit may be carried out in the foundry industry, and to develop industry-specific key performance indicators. Key figures and categorization of production systems should be something that every branch should agree upon. Introducing new key figures may pose some problems as there are often already well-established key figures in place, so an adjustment or perhaps a supplement to these may be needed. These measures will ultimately be necessary for the various providers of energy audits in order to be able to obtain consistent results.

Further research is required on how the unit process categorization for the production processes can be combined with the relevant KPIs developed within this study. Such research would facilitate the creation of a standard on how to uniformly structure industrial energy end-use data. The future will tell us if this is far too optimistic, even utopic, or if further research can help us gain such structure.

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