

Foundrybench D16 Results of benchmarking study

Grant agreement no. IEE/07/585/SI2.500402

Foundrybench

Foundry Energy Efficiency Benchmarking

Intelligent Energy – Europe (IEE)  
SAVE – Industrial Excellence in Energy

## **D16 Results of benchmarking study**

Document ID: Foundrybench\_D16\_20122011  
Revision [1.0]

Authors: Emma Svensson & Per Sommarin, Swerea SWECAST AB

Distribution: Public (PU)

Due date of deliverable: 30.9.2011  
Actual submission date: 20.12.2011

Start date of project: 1.1.2009

Duration: 36 months

Project coordinator :  
Sini Eronen  
Hermia Ltd.  
E-mail: [sini.eronen@hermia.fi](mailto:sini.eronen@hermia.fi)  
Tel: +358 40 820 4602

Project website: [www.foundrybench.fi](http://www.foundrybench.fi)

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## **1. SUMMARY**

### **2. BACKGROUND**

The aim of the benchmarking study was to make comparisons regarding energy performance between foundries. The plan was to make an energy efficiency ranking list of the participating foundries by calculating Energy Efficiency Indices (MWh/ton finished casting) from data collected via a benchmarking questionnaire. The ranking lists were going to be sent to the participating foundries in order to get feedback from the foundries on their reaction on the results of the study and to ask them about their interest in taking part in such a survey on an annual basis.

The results from the benchmarking study have not allowed the fulfilment of all these planned parts. The reasons for this are given in sections 2.4.1 and 3.1.3.

#### **2.1. QUESTIONNAIRE**

A questionnaire was developed and translated to the respective countries' languages. The questionnaire consisted of three parts.

The first part of the survey focused on the energy use of foundries on a general level. The aim was to use the results from this part of the survey to calculate energy related key indicators such as Energy Efficiency Index (EEI).

The plan was also to use the calculated EEI values for putting together ranking lists of the foundries regarding their energy efficiency. To make relevant comparisons and ranking lists the foundries were going to be divided into different categories, where foundries with similar prerequisites were put together in one ranking list. To allow this categorisation, the questionnaire asked for information from the foundries regarding their production on a detailed level. Detailed information regarding e.g. alloys, casting processes, types of furnaces, types and number of finishing processes etc. was necessary for a correct categorisation.

The second part of the survey evaluated the energy use of the foundries at a more detailed level. It also investigated how foundries work with energy issues (policies, if energy audit has been made, etc.).

The third and final part of the survey asked about the foundries view on barriers and driving forces with regard to energy efficiency.

To assure the responding foundries confidentiality, they left their answers with a "company code" instead of their company name. Only the Foundrybench partner in each country had a cross-list where company code and company name were matched.

The benchmarking questionnaire is described in more detail in Deliverable 12.

#### **2.2. DISTRIBUTION**

In total, 831 foundries received the questionnaire. The numbers of surveys distributed in each country are given in Table 1. For details, see also Deliverable 13.

**Table 1** *Number of distributed surveys*

<b>Country</b>	<b>Number of distributed surveys</b>
<i>Sweden</i>	<i>82</i>
<i>Germany</i>	<i>190</i>
<i>Finland</i>	<i>38</i>
<i>Italy</i>	<i>60</i>
<i>France</i>	<i>202</i>
<i>Spain</i>	<i>20</i>
<i>Poland</i>	<i>54</i>
<i>Slovakia</i>	<i>22</i>
<i>Czech Republic</i>	<i>13</i>
<i>UK and Ireland</i>	<i>150</i>
<b><i>In total</i></b>	<b><i>831</i></b>

A cover letter explaining the purpose of the questionnaire and briefly presenting the FoundryBench project was distributed together with the questionnaire. The cover letter is included in Appendix 2.

### **2.3. COLLECTION OF ANSWERS**

Answers were primarily collected via the benchmarking tool SurveyMonkey. Due to some technical difficulties, this programme complicated the collection of answers. For example some of the edit fields, where data should be filled in by the responding foundries, did not accept the answers that included a decimal sign. A PDF-version of the questionnaire was therefore created and the foundries that had troubles with SurveyMonkey could fill in that questionnaire instead.

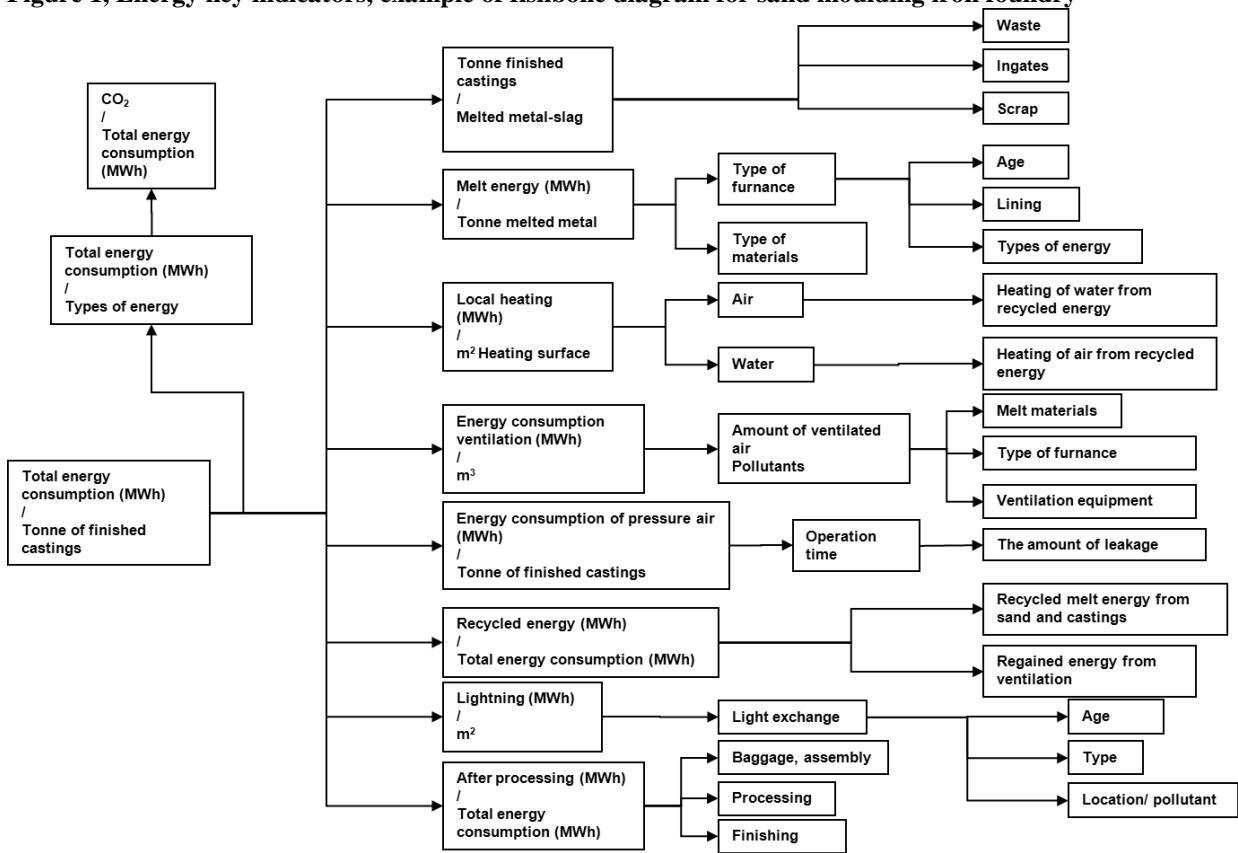
The partners in the Foundrybench project were responsible for distribution of the questionnaire as well as for sending out reminders and collect answers in their respective country.

A majority of the Swedish foundries that had not answered the survey after two reminders were contacted by phone. The partners in the other participating countries were encouraged to call the foundries in their country. Several of the partners did call some or all of their foundries, however, we do not know for sure how many foundries that were called in total.

### **2.4. ENERGY EFFICIENCY INDECES**

The Energy Efficiency Indeces are very useful tools for industries to keep track of their energy use. Key indicators can be monitored on several levels. Figure 1 shows an example of how an iron foundry could work with key indicators.

**Figure 1, Energy key indicators, example of fishbone diagram for sand moulding iron foundry**



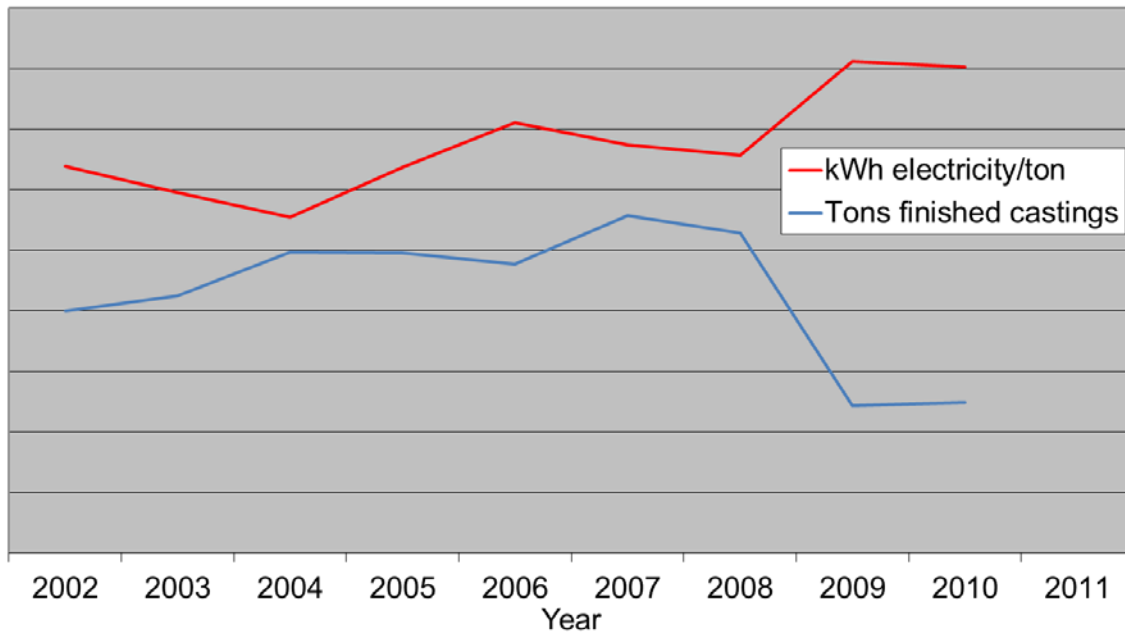
To the left, examples of overall key indicators are shown. These are the key indicators that depend on many factors in the production. In order to analyse more in detail what affect the key indicators have, sub key indicators can be monitored. The sub key indicators depend, in their turn, on many different impact factors, shown to the right in the figure.

For example, on an overall level, a foundry can choose to keep track on their total energy consumption per ton finished castings. This key indicator is dependent on both the energy use and the energy efficiency of the foundry, but it also depends on the production level. At times when the production is low, the support processes still run to more or less the same extent as when production is running on a high level. Heating of the premises might even require more energy when production runs less and produces less waste heat. The production processes in most cases run less efficiently when production is low, e.g. melting requires more energy per ton melted metal. These factors and others, cause energy use per ton casting to be higher at low production rate, affecting this key indicator, see one example in Figure 2.

Making a fishbone diagram for the own foundry can be an useful tool to map the connection between different key indicators and finding the impact factors that have an influence on the key indicators.

Figure 2, Example of how total electricity use/ton finished castings varies with the amount of total production

**Electricity use kWh/ton finished castings**



**2.4.1. Limitations regarding EEI values**

It is important to point out that the EEI values have to be used with caution when it comes to comparing EEI values between different companies. EEI values should primarily be used to make comparisons within the own foundry. I.e. a foundry should follow its EEI values from year to year or month to month to keep track of their energy use. Comparisons between foundries should be made with care. The reason for this is that the foundries have very different prerequisites and comparisons between foundries are therefore only of very limited value and interest if not done correctly.

System boundaries are issues that cause difficulties regarding comparisons. The number and range of activities performed varies a lot between foundries. Some foundries might have in-door fettling, heat- and/or surface treatment while other foundries outsource those activities. In order to make relevant comparisons, all this type of background data needs to be considered. The benchmarking questionnaire used in this study asked for information regarding issues like these, but unfortunately, far from all foundries filled in this data. Comparing the energy use of two foundries with very different operations would obviously be of no interest or use.

However, EEI values could be used to compare the efficiency of specific processes between foundries, e.g. compare the melting process of one foundry with that of another. This way, the system boundaries would be the same, ensuring relevant comparisons.

### 3. RESULTS

#### 3.1. ENERGY EFFICIENCY INDECES

##### 3.1.1. Number of answers

The approximate minimum targets for completed, returned questionnaires are given in Table 2:

**Table 2 Number of expected and received answers**

Country	No. of expected answers	No. of actual answers
Finland	15	10
Germany	25	15
Sweden	25	23
Poland	10	9
France	20	14
UK	10	0
Spain	10	7
Italy	10	3
Other EU- countries	10	0
Total	135	81

##### 3.1.2. Energy Efficiency Index calculations

Overall EEI values were calculated for all foundries where enough data was available from the questionnaire. However, some of the EEI values can be questioned since they are lower than can be reasonably expected. EEI values below 2 are considered to be notably low. However, in a large iron foundry, it is possible to reach such a value. For steel and metal foundries, it is more unlikely.

In figures 3 to 8 the EEI values per country are given for each type of foundry, iron, steel and metals (including aluminium, zinc and copper).

For the iron foundries it may be possible to draw the conclusion that the foundries in the northern countries, Sweden and Finland, have slightly higher EEI values than the foundries with a more southern location (two foundries in Poland excluded). The colder climate in Sweden and Finland could explain the higher energy use per ton finished casting.

Figure 3, EEI values for iron foundries

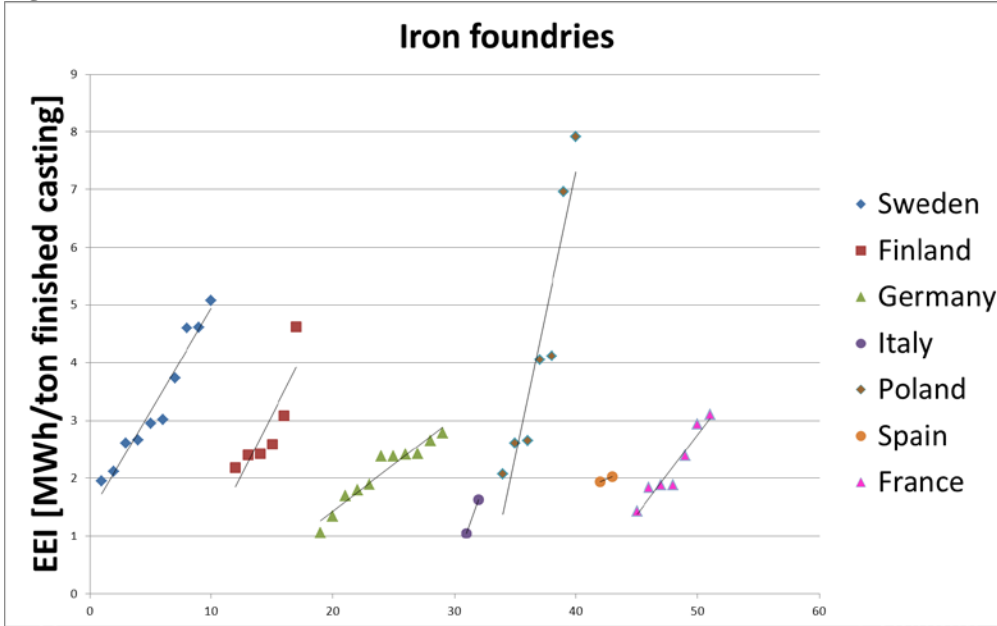
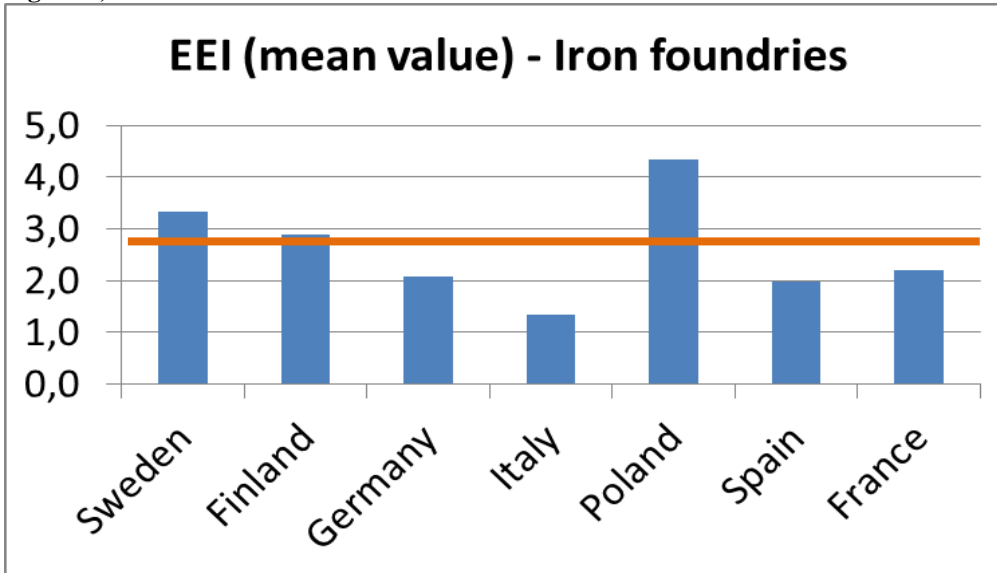


Figure 4, mean EEI values for iron foundries



For the steel foundries, there were few answers, which limit the possibilities for evaluation. EEI values of steel foundries in Sweden, Finland and France are higher than for Germany, Italy and Spain. Value for Italy can be questioned since it is notably low.

Figure 5, EEI values for steel foundries

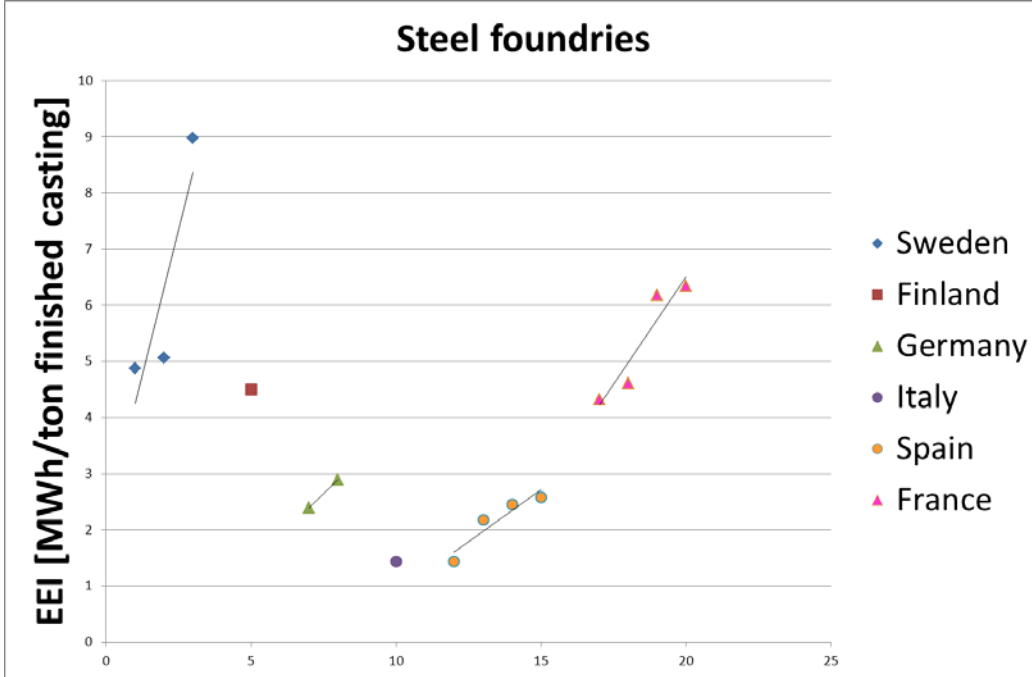
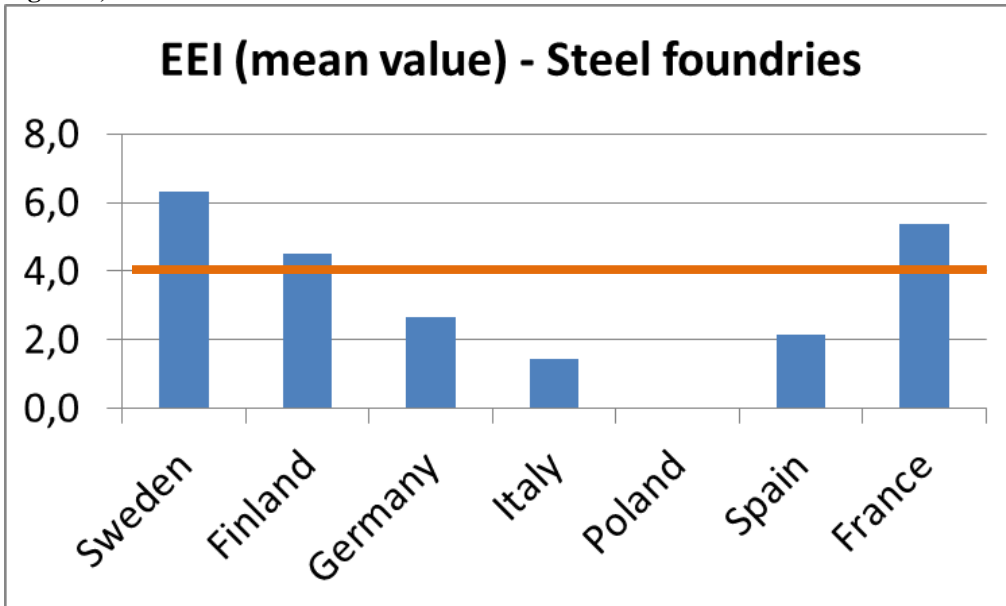


Figure 6, mean EEI values for steel foundries



For the metal foundries it is impossible to see any kind of trend or logic.

Figure 7, EEI values for metal foundries

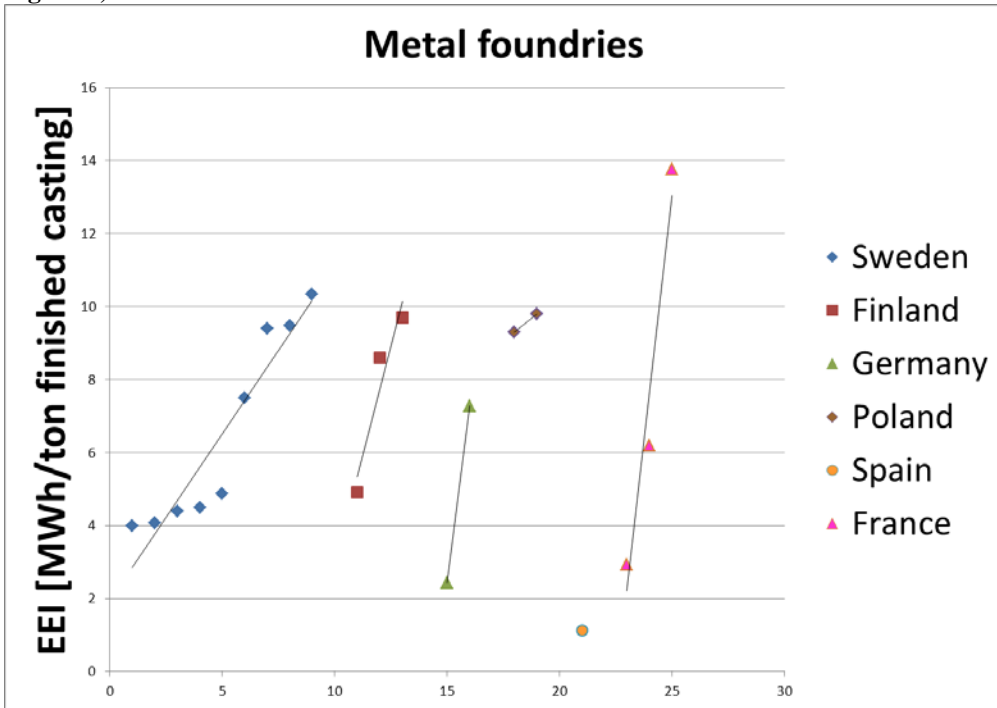


Figure 8, mean EEI values for metal foundries

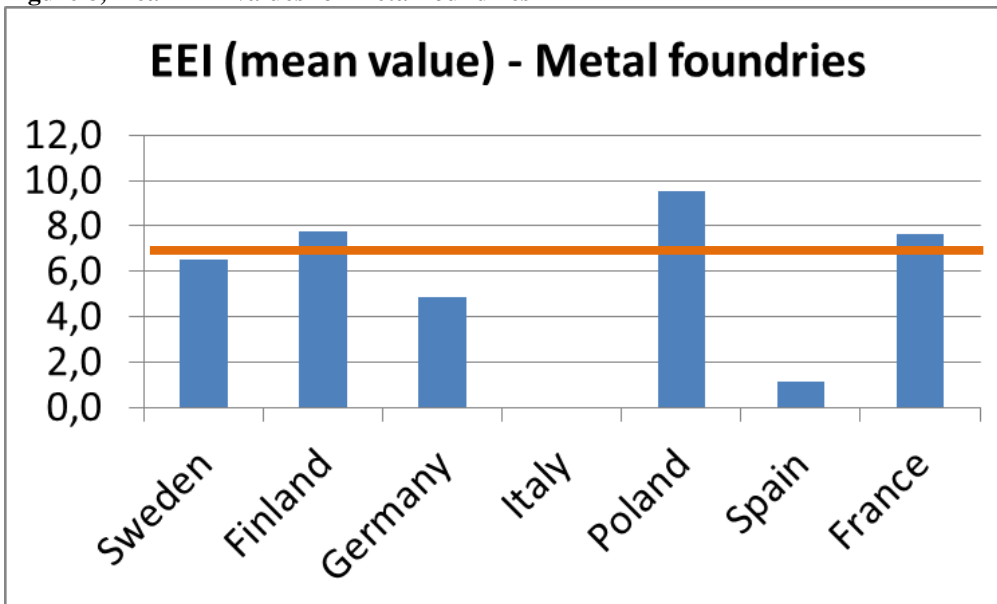


Table 3 shows the mean EEI values for all countries as well as the total average value for iron, steel and metal foundries, respectively.

**Table 3, Mean EEI values**

Country	Iron	Steel	Metals
Sweden	3,3	6,3	6,5
Finland	2,9	4,5	7,7
Germany	2,1	2,6	4,9
Italy	1,3	1,4	No data
Poland	4,3	No data	9,6
Spain	2,0	2,2	1,1
France	2,2	5,4	7,6
Average (all countries)	2,8	4,0	6,7

### 3.1.3. Discussion

The number of answered surveys was less than expected. A lot of effort was put in to reach the number of answers that we finally managed to collect. Considering the limited data, we are only able to draw a few conclusions.

The mean EEI values for all foundries within one foundry type (disregarding which country the values derive from), shows a pattern that was expected. Iron foundries have the lowest EEI value, it is somewhat higher for steel foundries and highest for metals foundries.

For the iron foundries there is a slight trend that the foundries in the northern countries, Sweden and Finland, have a little higher EEI values than the foundries with a more southern location (two foundries in Poland excluded). The colder climate in Sweden and Finland could explain the higher energy use per ton finished casting. Different legalisation and ambitions to offer good working conditions (temperature and ventilation) could also be factors to take under consideration when comparisons between countries are being made.

The evaluation of the answers on a more detailed level had to be excluded. For example, there was a plan to evaluate the Energy Efficiency Index for heating to make comparisons out of a climate perspective. From the received answers it was however impossible to find out which energy had been used for heating and which had been used for other purposes. To contact all foundries to ask for completing information would imply more work hours than would be reasonable for this work package, so that was not a realistic solution.

The reasons for the low response rate are expected to be several.

First of all, the survey was quite extensive and detailed. The details were going to be used for the categorisation for the ranking lists. However, the extent of the survey resulted in that many foundries did not take the time to fill in their answers. Several foundries were contacted by telephone and reminded to answer.

A vast majority of the (Swedish) foundries that we called to encourage to answer the survey, clearly stated that at the current time, they had no time to spend on this. We emphasized that parts of the survey were voluntary and that they could fill in the parts where they had information readily available. It had little impact.

Another reason for low response rate was that the foundries contacted by phone indicated that they did not have the information asked for in the survey easily available. I.e. they don't monitor their energy consumption on a regular basis. Of course, the foundries have an interest in their energy cost and want to decrease it. However, far from all have reached the next step: to analyze the energy use in more detail on a regular basis, in order to know where to make the primary energy saving efforts.

It seems that if the foundries had kept track of their energy use on a regular basis, the survey could have been answered relatively quickly. The lack of monitoring is surprising since the cost for energy constitute a relatively large part of the added value for castings.

Another reason is that there was a boom in the foundry industry at the time for the distribution of the questionnaire. The industry was leaving a recession and they put focus on increasing their production rate to meet the expectation of their customers.

Yet one more reason is that the foundries are asked to fill in a large amount of different kind of surveys. They simply think that they spend too much time filling in questionnaires. One Swedish foundry even said that it is their policy to never take part in surveys of any kind.

The choice to use a questionnaire was based on the possibilities to collect data from as many foundries as possible. However, considering the poor result from the questionnaire, it would have been better to evaluate fewer foundries and instead make personal interviews with some selected foundries. This way, there would have been much better possibilities to verify the data and to make sure that the same system boundaries were used for all foundries.

When it comes to the poor quality of the collected data, we believe that at most foundries, several persons needed to be involved in order to contribute with data to be able to fill in the complete survey. In most cases, this was probably not done which could be an explanation to the uncertain and sometimes strange data. The person that keeps track of production volumes might not be the same person that can answer questions regarding whether an energy audit has been performed or not. A third person might be needed to get information regarding turnover etc. The need to involve several persons in collecting the data was probably a barrier for the foundries to fill in the questionnaire especially since the workload for the time of the survey was high at most foundries.

In some cases we have had no possibilities at all to verify or correct questionable data. The reason was that in some cases there were no cross-lists available, where the company code and company names were matched. In that case it was impossible for us to trace which foundry had supplied certain data giving no possibilities to verify or complement the data.

We had to spend a lot of time trying to correct strange data. It could be that the magnitude of the provided data was unreasonable; we could for example see that the wrong unit has been used. In some cases we could correct it, while in others we had no way of knowing what would be the right unit to base the calculations on etc. Despite that a lot of time was spent trying to correct data, many strange values remained.

However, the Foundrybench partners have gained a lot of valuable knowledge from this project, knowledge that can be used when the partners continue the work in their own nations.

#### **3.1.4. Limitations because of low response rate and poor quality of data**

Since the number of completely answered surveys is so low, the possibilities to draw firm conclusions would be limited even if the questionnaires would have been filled in completely. The fact that the quality of the collected data is quite poor and uncertain, even more limits the reliability of the study.

When the goals for this benchmarking study were setup, the foundries' interest and detailed knowledge of their energy use was somewhat overrated. Even if the foundries have an ambition to cut the energy costs, they have not always taken the next steps and started their work with getting an overview and detailed knowledge of their energy use, as well as keeping track of it on a regular basis. This caused the collection of

quite uncertain data with unclear system boundaries. Considering the lack of relevant background data, it is not valuable to make ranking lists as planned.

## 3.2. BARRIERS AND DRIVERS FOR ENERGY EFFICIENCY, ENERGY SERVICES AND ENERGY MANAGEMENT

One part of the survey evaluated the foundries' view on barriers against and driving forces for energy efficiency. The aim of this part of the study was to study factors which promote and inhibits energy efficiency.

### 3.2.1. Number of answers

This part of the questionnaire received 65 full answers. Considering the fact that 831 questionnaires were sent out, this gives an answer frequency of 8 %.

An overview of collected responses is shown in Table 4.

**Table 4: Overview of collected responses, barriers and drivers part of the questionnaire. (SE: Small Enterprise, ME: Medium-sized Enterprise, LE: Large Enterprise)**

	Cast Iron			Cast Steel			Copper			Aluminium		
	SE	ME	LE	SE	ME	LE	SE	ME	LE	SE	ME	LE
IT	1	0	1	0	0	1	0	0	0	0	1	0
FR	2	2	1	1	1	0	0	0	0	1	0	2
FI	0	0	0	0	0	1	1	0	0	2	0	0
GE	1	5	6	0	1	1	0	0	0	0	2	0
PO	1	1	1	0	0	1	0	0	0	1	1	0
SP	1	1	0	1	2	0	0	0	0	0	0	0
SW	8	1	0	3	1	0	2	0	0	4	1	0

### 3.2.2. Result - Barriers

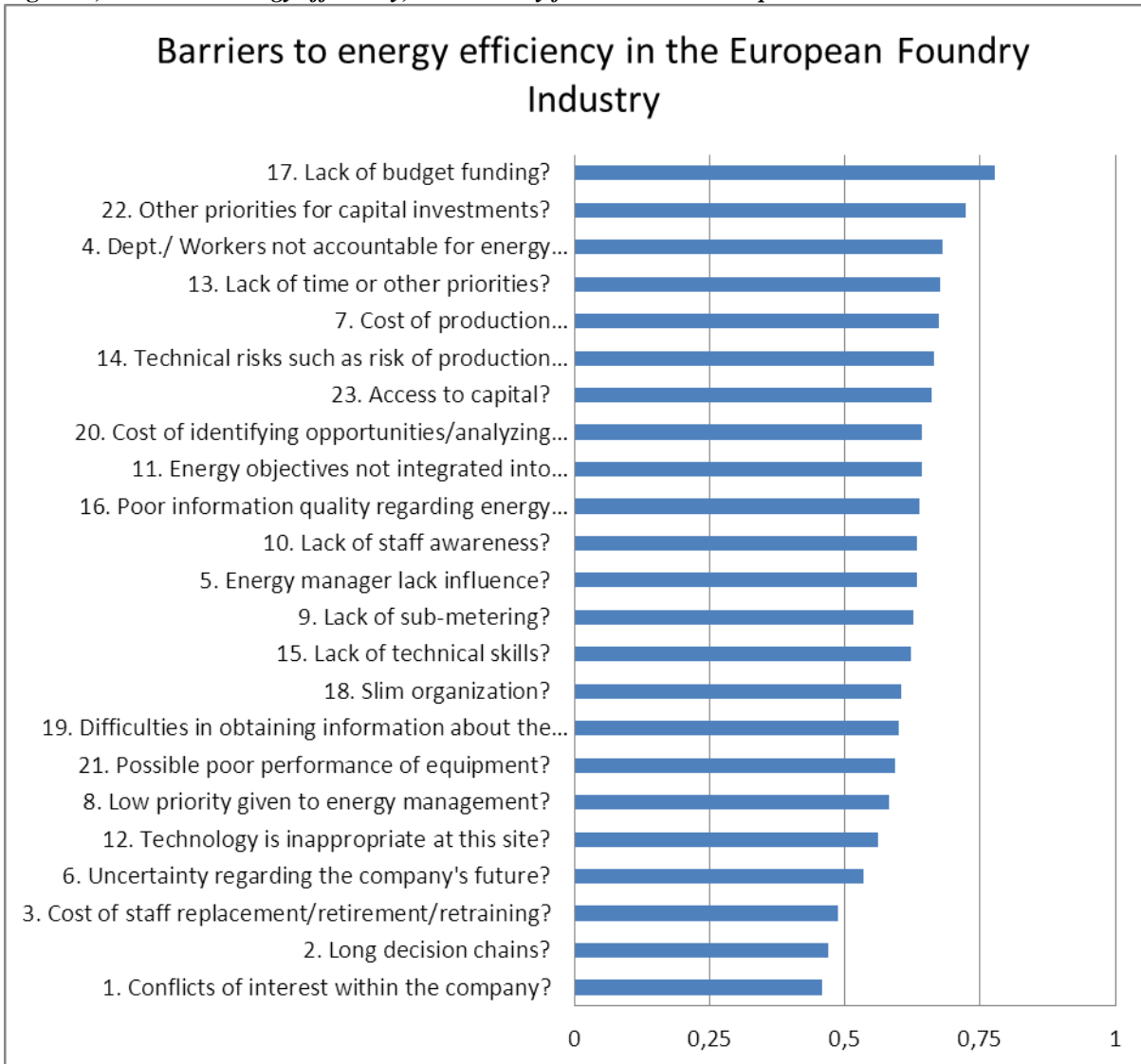
The foundries were asked to answer the following question: “According to the aggregated experience in your company, how do you value the following barriers impact on the implementation of cost-effective energy efficiency measures at your company?”.

The answering alternatives were:

- no impact
- almost no impact
- neutral
- some impact
- major impact

The barriers that are perceived as having the highest impact are related to economic factors, such as lack of budget funding and other investment priorities, see Figure 9.

**Figure 9, Barriers to energy efficiency, as ranked by foundries in 7 European countries**



**3.2.3. Result - Drivers**

The respondents were asked to answer the following question: “According to the aggregated experience in your company, how do you value the following factors impact on the implementation of cost-effective energy efficiency measures at your company?”.

The answering alternatives were:

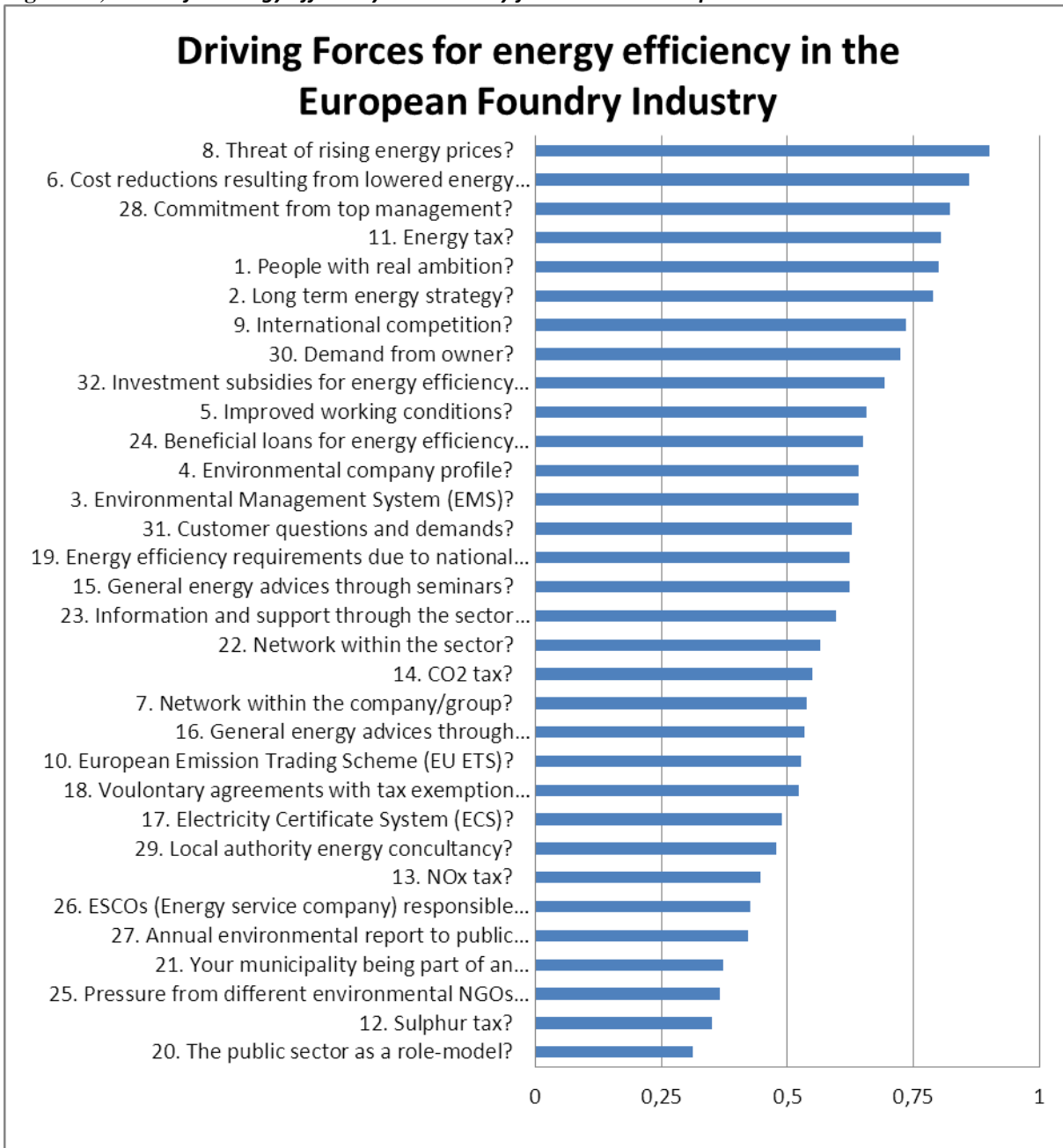
- no impact
- almost no impact
- neutral
- some impact
- major impact

The highest ranked drivers were threat of raising energy prices and cost reductions from energy savings, two factors that are closely related, since the savings from an investment in energy efficiency depend on the price

of energy. Projects involving the public sector, the local municipality or other external parties are ranked as having very low impact as a driver for energy efficiency, see Figure 10.

The full result from this part of the study is found in Appendix 1.

**Figure 10, Drivers for energy efficiency as ranked by foundries in 7 European countries**



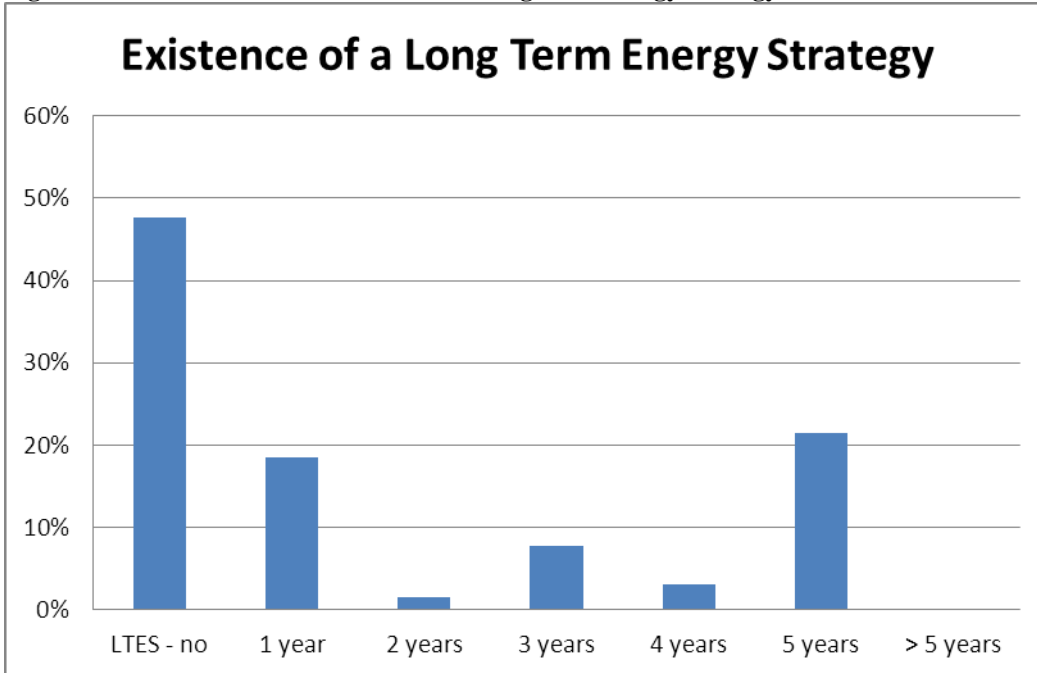
**3.2.4. Result - Energy services and in-house energy management practices**

This part of the study aimed to study the degree of implementation of a variety of energy services and in-house energy management practices, in the European foundry industry. The answer frequency was the same

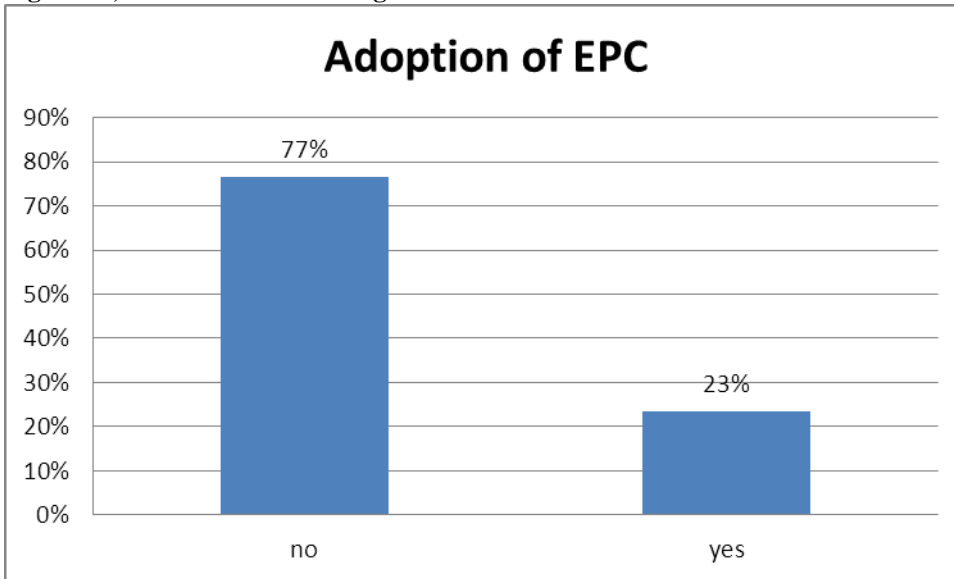
as for the barriers and drivers part of the questionnaire, see section 3.2. Linköping University, department for Energy Systems, did the evaluation of this part of the benchmarking. The full result is found in Appendix 1.

Nearly half of the studied foundries lack a long-term energy strategy, see Figure 11. This is noteworthy since previous research has shown that a long-term energy strategy is one of the highest ranked factors promoting energy efficiency in industry.

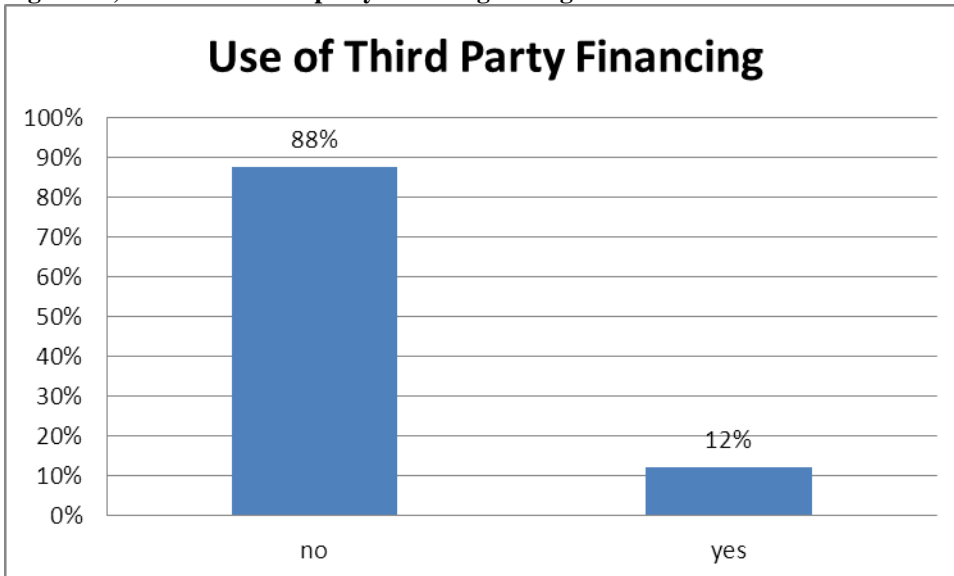
**Figure 11** The existence and duration of a long-term energy strategy at the studied foundries.



23 % of the studied foundries state that they have used EPC (Energy Performance Contracting), see Figure 12. Notably, the foundry respondents rank lack of budget funding as the major barrier to energy efficiency and EPC as a successful tool for carrying out investments without affecting of the company budget.

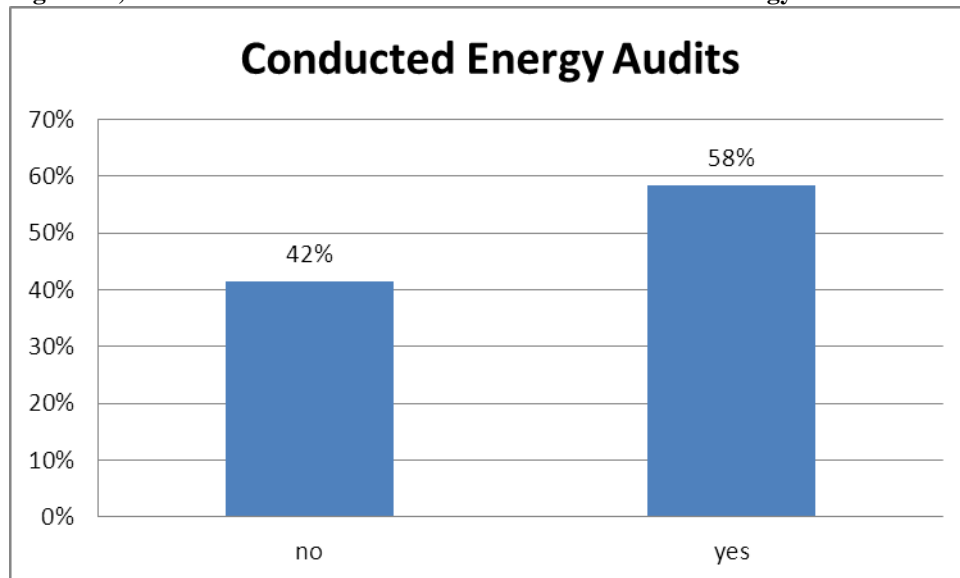
**Figure 12, The use of EPC among the studied foundries**

Only 12 % of the studied foundries have used third party financing, see Figure 13.

**Figure 13, The use of third party financing among the studied foundries**

Among the studied foundries, 58 % have conducted an energy audit, see Figure 14. Since conducting an energy audit is the first step in starting up an energy efficiency work, this shows a large potential for improvement.

**Figure 14, The number of foundries which have conducted an energy audit.**



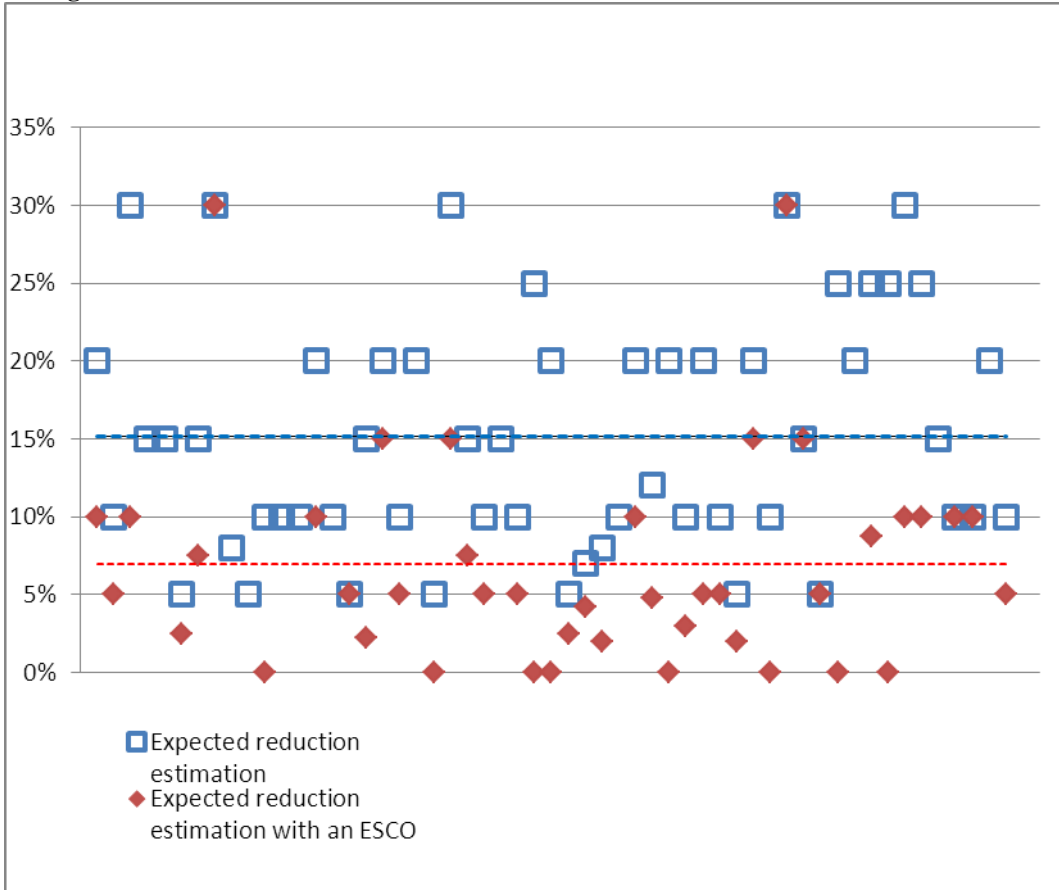
However, there is a large difference between the different countries where Germany followed by Sweden shows the largest adoption/use of energy audits, see Table 5. This could in turn be related to the respective nation’s policy program towards the adoption of energy audits. Germany has for example a history of energy audit programs. In Sweden there is currently a program for financial support for companies that conduct an energy audit.

**Table 5, The use of energy audits among the studied countries’ foundries.**

Nation	AUDIT - yes	AUDIT - no
Italy	25%	75%
Spain	60%	40%
France	40%	60%
Germany	75%	25%
Poland	33%	67%
Sweden	70%	30%
Finland	50%	50%

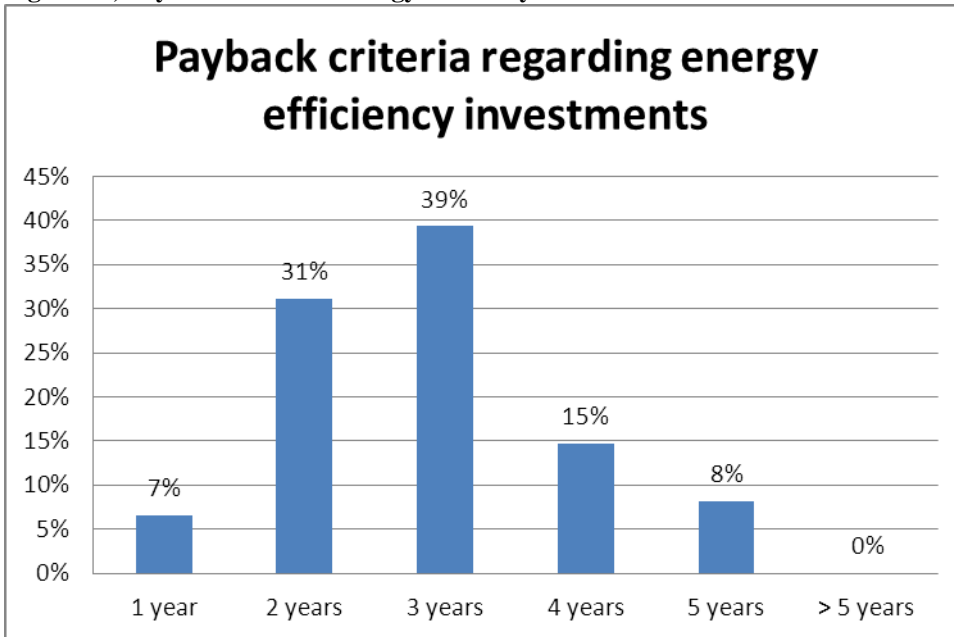
The foundries were also asked to estimate the overall energy efficiency potential in their company. The potential was on average estimated to 15 %. Out of this amount, they estimate that 46 % of the potential, i.e. 7 % could be deployed consulting an ESCO (Energy Service Companies).

**Figure 15, Aggregated energy efficiency potential and expected deployment levels from consulting an ESCO, among the studied foundries.**



Among the studied foundries, the majority are having payoff criteria of 3 years or less (77 %).

**Figure 16, Payoff-criteria for energy efficiency investments.**



**3.2.5. Discussion**

This study has shown a major improvement potential for both technical energy efficiency measures and improvement in the energy management practices in the European foundry industry. Increasing energy prices in Europe have raised the awareness of the importance of energy efficiency. Energy conservation has become significant not only for environmental reasons but also for economic reasons and to remain competitive. The foundry industry has an energy intensive production and therefore industrial energy efficiency becomes especially important. Despite a large untapped potential for improved energy efficiency, many energy efficiency investments are not undertaken due to the existence of barriers to energy efficiency. In order to achieve a world-leading European foundry industry, these barriers must be detected and removed. A number of driving forces for energy efficiency has been stated in the literature. The importance of asking the actual industry of their perception of barriers and drivers is naturally of great importance. Setting up an in-house energy management program, or consulting an ESCO (Energy Service Company) are two major means for industry in improving energy efficiency according to the EU Commission wherefore special attention on these issues should be given, in order to achieve improved energy efficiency in the European foundry industry.

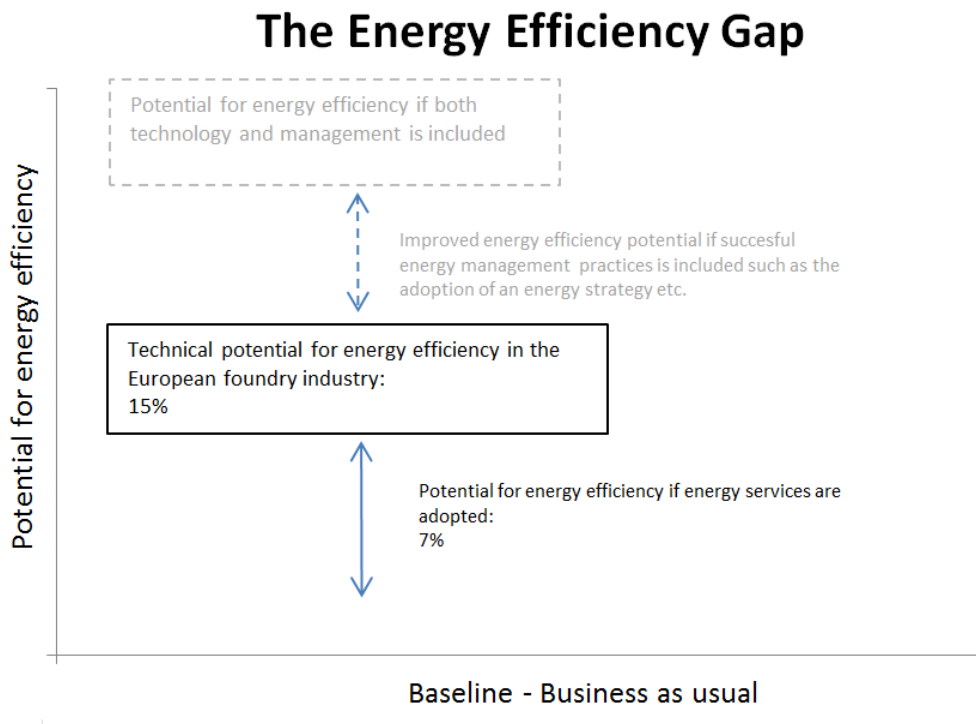
The barriers that are perceived as having the highest impact are related to economic factors, such as lack of budget funding and other investment priorities. The highest ranked drivers were threat of raising energy prices and cost reductions from energy savings, two factors that are closely related, since the savings from an investment in energy efficiency depend on the price of energy. Projects involving the public sector, the local municipality or other external parties are ranked as having very low impact as a driver for energy efficiency.

Nearly half of the studied foundries lack a long-term energy strategy, 23 % state that they have used EPC (Energy Performance Contracting), and 12% have used third party financing. Among the studied foundries, 58% have conducted an energy audit. The overall energy efficiency potential is on average stated to be 15%,

among where 46 % of the potential, i.e. 7 % could be deployed consulting an ESCO. Among the studied foundries, the majority are having payoff criteria of 3 years or less (77 %).

In conclusion, this study has shown a major improvement potential for both technical energy efficiency measures and improvement in the energy management practices in the European foundry industry. Figure 17 show the stated potential for energy efficiency in the European foundry industry as well as the potential for energy services.

**Figure 17, The potential for energy efficiency in the European foundry industry as well as the potential for energy services.**



Further research based on the results from this study can help understand what measures, e.g. public policies, could help diminish the energy efficiency gap and increase energy efficiency in European foundry industries.

#### 4. FEEDBACK FROM FOUNDRIES

The initial plan was to make a ranking list of the foundries, in different categories, in order to let the foundries compare their energy efficiency level with each other. The ranking list was going to be sent to the foundries together with another questionnaire, where the plan was to ask for feedback from the foundries regarding the results of the benchmarking study.

Since there is no value in making a ranking list, this activity has not been carried out. Also, the individual feedback to the foundries has not been made yet. The plan is that each country, if it is considered as useful, will send the EEI values to the responding foundries in their country, in order for the foundries to be able to compare their own EEI with other foundries.

Initially, the plan was to send out yet another questionnaire to the foundries, to ask for their feedback regarding the benchmarking results. Considering the fact that the foundries already think that they receive

too many questionnaires, this activity has not been carried out. It could be counterproductive for future studies to bother the foundries with more questions at this stage.

There have been concerns about how the EEI values could be used to control or put requirements on foundries regarding their energy efficiency performance. Considering the limitations of calculated values and the factors pointed out in section 2.4, it should be clear that the EEI values are not to be used in this way. Comparisons between specific processes could be relevant, but still, comparing EEI values could possibly be an inspiration for the foundries to find out that there might be more activities that they could carry out. To use EEI values to put up requirements on foundries could be very misleading. Like mentioned before, the foundries have very different prerequisites and you need to be sure that you make correct comparisons.

However, project partners have had discussions with some foundries that answered the questionnaire. The feedback from the foundries has been of various kinds. On one hand, the foundries see no risk in exchanging information regarding their energy efficiency work (at least this is the case in Sweden). They are quite open and can even consider cooperating on these issues as they are not directly affecting the competition between the foundries. Some Swedish sand moulding foundries have started a network where they discuss and compare energy related key indicators on their support processes (ventilation, lighting, compressed air etc.). On the other hand, the foundries express a worry concerning the comparison of key indicators. The reasons are the ones discussed previously in this report.

## **5. CONCLUSIONS**

This study has shown a major improvement potential for both technical energy efficiency measures and improvement in the energy management practices in the European foundry industry.

Foundries have much to gain by increasing their awareness of their energy use. In many cases there are technical solutions available. Economic barriers hinder the implementation but could be eliminated by a higher implementation of third party financing and cooperation with an ESCO. The method used to calculate whether an investment is profitable or not should also be reviewed. Changing the payback criteria for energy efficient equipment could be appropriate and give other opportunities for investments like LCC etc.

It should be pointed out that there could be all the technical solutions in the world to achieve energy efficiency, but if there is no will to implement them there will not be any effect. More focus should therefore be put on the management issues in the companies.

New project combining the issues: energy efficiency, economy and management issues could help the industry to be more competitive.

## LIST OF ATTACHMENTS:

Appendix 1 A study of barriers to and drivers for energy efficiency in the foundry industry in Finland, France, Germany, Italy, Poland, Spain and Sweden

Appendix 2 Cover letter for questionnaire