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Foundrybench

Foundry Energy Efficiency Benchmarking

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

D16 Results of benchmarking study, 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

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1. SUMMARY

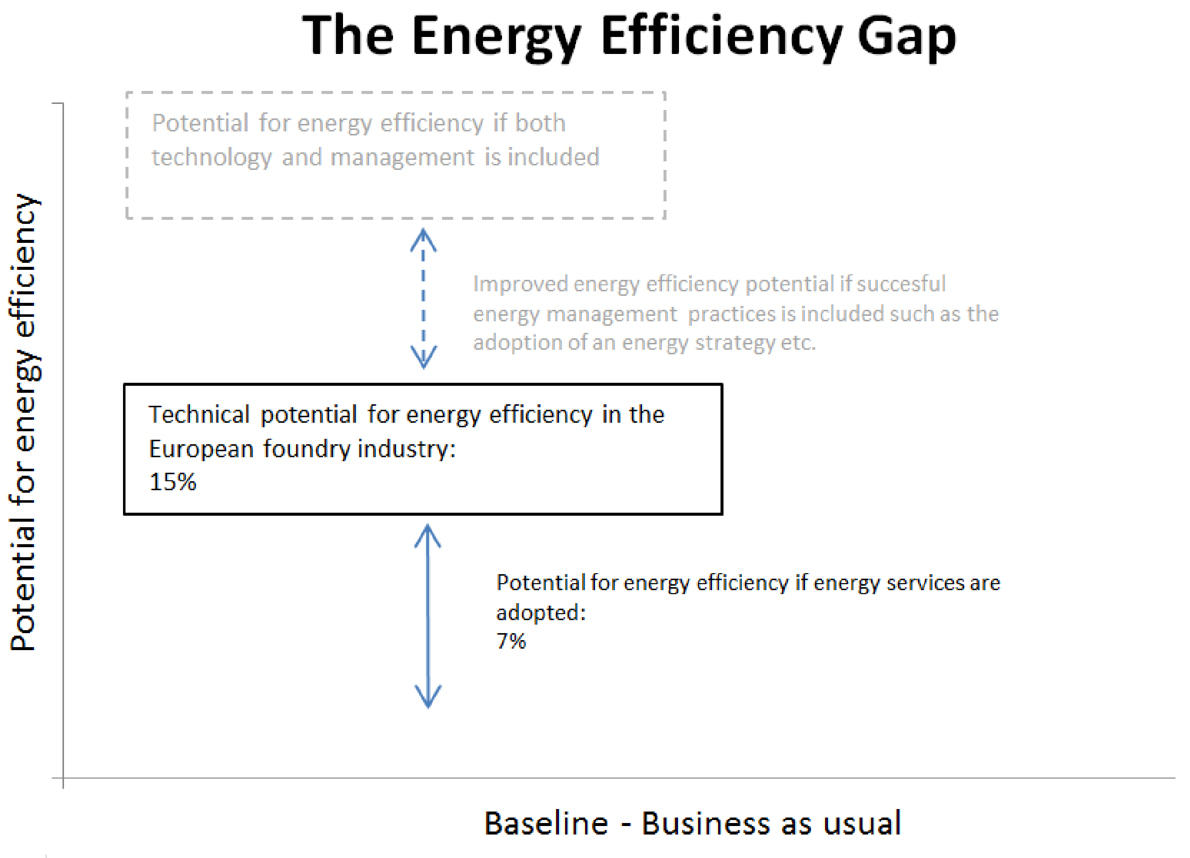
Increasing energy prices in Europe have raised the awareness of the importance of energy efficiency. Energy conservation has become significant not only for environmental reasons but also for economic reasons and to remain competitive. The foundry industry has an energy intensive production and therefore 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 addition to studying barriers and rivers, in order to achieve improved energy efficiency in the European foundry industry. The aim of this study is to i) study factors which promote and inhibits energy efficiency, and ii) study the degree of implementation of a variety of energy services and in-house energy management practices, in the European foundry industry.

This study is the result of the project Foundry Bench and has been carried out in collaboration between Linköping University (Sweden) and Swerea SWECAST (Sweden) concerning barriers to- and drivers for energy efficiency, energy services and energy management, among European foundries. A questionnaire has been sent out in the beginning of 2011 to foundries in Finland, France, Germany, Italy, Poland, Spain and Sweden regarding, e.g. factors that prevents and motivates their implementation of cost-effective energy efficiency measures. The questionnaire was sent out to 831 foundries, with a response rate of 125 answers, among where 65 fully answered the questionnaire. This gives an answer frequency of 8 % of full answers and 15 % including the ones which were partly answered.

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, according to the respondents, is on average stated to be 15%, among where 46 % of the potential, i.e. 7 % could be deployed consulting an ESCO (Energy Service COmpanies). 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 1 show the stated potential for energy efficiency in the European foundry industry as well as the potential for energy services.

Figure 1, ***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.

2. INTRODUCTION

The issue of climate change due to, in particular anthropogenic emissions of CO_2 is forcing decision-makers to make decisions towards more efficient use of energy. Industrial energy efficiency is stated to have a key role in the transition into more carbon-neutral energy systems. Increasing energy prices in Europe have moreover 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. (Rohdin et al 2006)

The word efficiency implies cost effective resource allocation; reducing industrial energy use decreases production costs and thus it improves competitiveness. Despite a need for increased industrial energy efficiency, studies indicate that energy efficiency is not implemented to the extent that would be most cost-effective. The inefficient use of energy is referred to as the energy efficiency gap. The energy efficiency gap is, in academic literature, explained by barriers to energy efficiency. Studies on barriers (and drivers) to energy efficiency is a fairly new research field, outlining economic, organizational and behavioural factors that inhibit cost-effective investments in energy efficiency. (Jaffe and Stavins 1994: Sorrell et al. 2004, Thollander 2008)

Despite a large untapped potential for improved energy efficiency, many energy efficiency investments are thus 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 addition to studying barriers and rivers, in order to achieve improved energy efficiency in the European foundry industry. The aim of this study is to i) study factors which promote and inhibits energy efficiency, and ii) study the degree of implementation of a variety of energy services and in-house energy management practices, in the European foundry industry.

This study is the result of the project Foundry Bench and has been carried out in collaboration between Linköping University (Sweden) and Swerea SWECAST (Sweden) concerning barriers to- and drivers for energy efficiency, energy services and energy management, among European foundries.

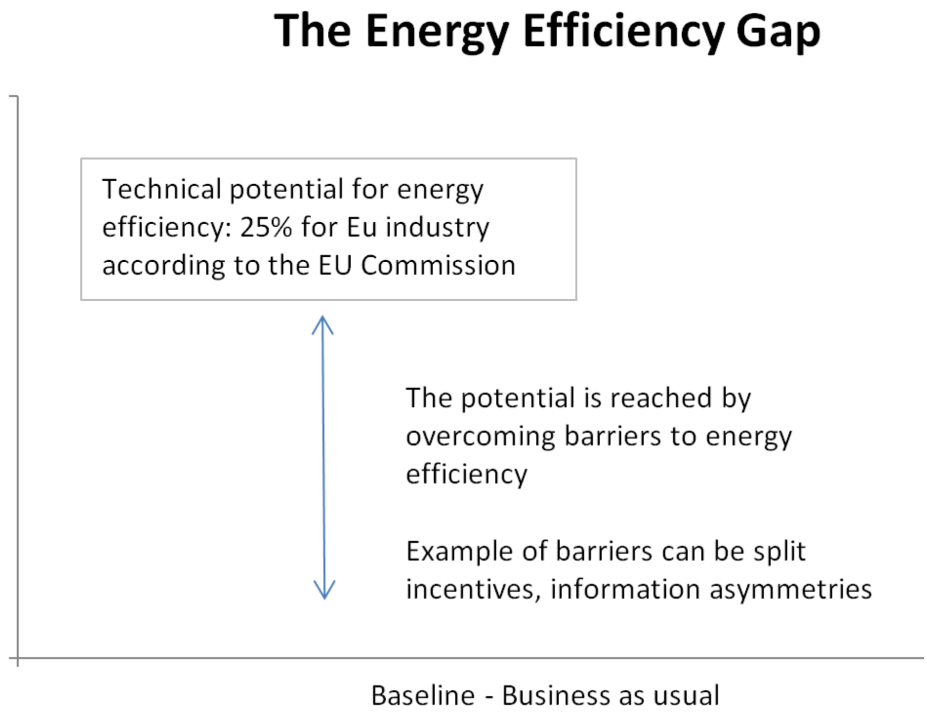
3. BARRIERS TO AND DRIVERS FOR ENERGY EFFICIENCY, ENERGY SERVICES AND ENERGY MANAGEMENT

3.1. BARRIERS TO AND DRIVERS FOR ENERGY EFFICIENCY

Numerous empirical studies in various industrial and public sectors have illustrated the existence of an energy efficiency gap. Energy as a resource is not being used as efficiently as it could; there is an untapped reservoir of cost–effective technologies that are not being employed even though they could substantially improve the energy end-use. This efficiency gap occurs in all sectors of society, households, public buildings, institutions and private industries. (DeCanio 1993, DeCanio 1998, Jaffe and Stavins 1994a-b) Since the foundry industry is an energy-intensive sector, inefficient use of energy is an increasing challenge for European foundries as electricity and fuel prices are expected to increase.

The energy efficiency gap is commonly explained by barriers to energy efficiency, see Figure 2.

Figure 2, ***Explaining the energy efficiency gap (Thollander, 2011).***



The categorisation of barriers differs depending on the scientific discipline presenting the barriers. The European Commission in the Energy End-Use Efficiency and Energy Services Directive (ESD; 2006) categorize barriers in to market imperfections (market failures) and market barriers. A market imperfection/failure is the economic term for deviations that disrupt the conditions on a perfect market. A perfect market contains: rational actors, no barriers to enter or exit the market, homogenous products, an infinite number of actors and sellers, perfect information, perfect factor mobility, constant returns to scale and costless transactions. If any of these assumptions does not hold, a market failure exists. Market barriers are a wider term than market failures and it is used to explain why investments with high rate of return are being neglected; the term includes economic, behavioural and organizational factors. Barrier models have been the widely accepted reason for the energy efficiency gap, e.g. in the European Commission energy end-use and energy services directive (EC, 2006).

A number of studies have investigated barriers to energy efficiency empirically (Schleich and Gruber, 2008). Many of the empirically spotted barriers may however be categorized as market failures. (Rohdin and Thollander, 2006; Rohdin et al., 2007; Thollander et al., 2007). Understanding the barriers, what prevents industries from making investments in energy efficient technologies is important to help overcome the gap. A gap that need to be shrunk, not only for economic but also for environmental reasons. Several studies have already investigated barriers to energy efficiency in the Swedish foundry industry. In 2005, Rohdin and Thollander concluded that the main barriers to increased energy efficiency in Swedish foundries were access to capital, high technical risks and lack of budget funding.

However, to improve energy efficiency, it is also important to understand what drives companies to increase energy efficiency. Drivers for energy efficiency are a relatively new research field since it has previously been assumed that economic reasons are the main drivers. But since the barrier theory has proven that behavioural and organizational factors often hinder investments in energy efficiency they can also drive the undertaking of increased efficiency. Previous empirical studies has illustrated the importance of public policies and organizational and behavioural driving forces as well as external driving forces for implementing cost-effective energy efficient energy technologies. In 2008 Thollander performed a study on drivers for increased energy efficiency in Swedish foundries. The main finding was that the importance of having a person engaged in energy questions at the industry was the most important driver. Economic factors such as reducing energy costs and the threat of raising energy prices were also highlighted as important drivers.

The fact that economic factors have a large effect on the energy utilization in the foundry industry can be understood in Figure 3. The diagram illustrates that the relative use of electricity compared with total energy use, in foundries in six European countries was almost inversely related to the price of electricity in 2005.

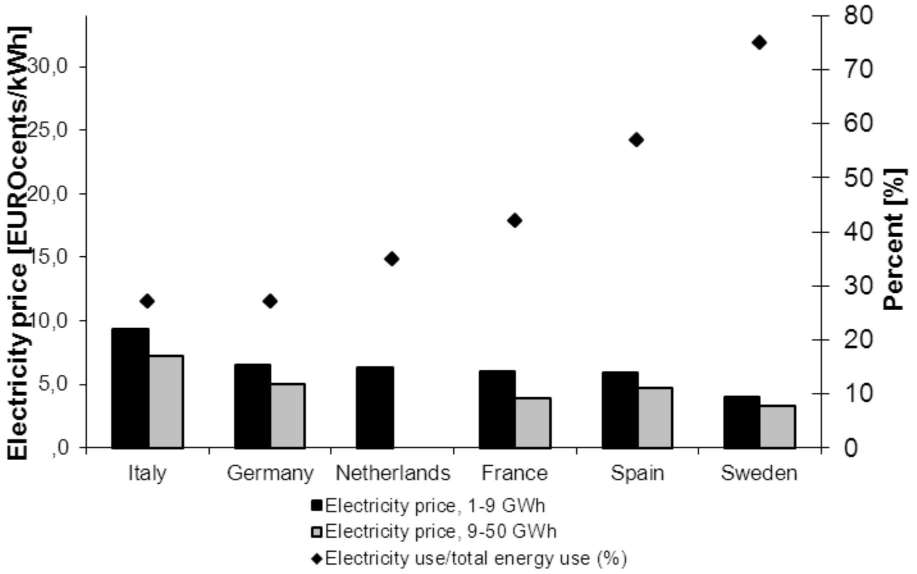


Figure 3, ***Electricity use in relation to total energy utilization (%) in foundries that utilizes 1- 50 GWh per year in Italy, Germany, Netherlands, France, Spain and Sweden. (Thollander 2008).***

For further analysis of the questionnaire, the barriers to energy efficiency could be analysed from a more theoretical approach. The barrier theory is derived from mainstream economics, organizational economics and organizational and behavioural theories.

Barriers can be divided into three broad categories: Economic, Organizational and Behavioural. In table I, a review of the existing literature on barriers to energy efficiency is presented. (Sorrell 2000; Thollander et al. 2010)

Table 1, *Barriers to energy efficiency. (Cited from Thollander et al 2010)*

Theoretical Barriers	Comment
Imperfect information	Lack of information may lead to cost-effective energy efficiency measures opportunities being missed.
Adverse selection	If suppliers know more about the energy performance of goods than purchasers, the purchasers may select goods on the basis of visible aspects such as price.
Principal-agent relationships	Strict monitoring and control by the principal, since he or she cannot see what the agent is doing, may result in energy efficiency measures being ignored.
Split incentives	If a person or department cannot gain benefits from energy efficiency investment it is likely that implementation will be of less interest.
Hidden costs	Examples of hidden costs are overhead costs, cost of collecting and analysing information, production disruptions, inconvenience etc.
Access to capital	Limited access to capital may prevent energy efficiency measures
Heterogeneity	A technology or measure may be cost-effective in general, but not in all cases.
Form of information	Research has shown that the form of information is critical. Information should be specific, vivid, simple, and personal to increase its chances of being accepted.
Credibility and trust	The information source should be credible and trustworthy in order to successfully deliver information regarding energy efficiency measures. If these factors are lacking this will result in inefficient choices.
Values	Efficiency improvements are most likely to be successful if there are individuals with real ambition, preferably represented by a key individual within top management
Inertia	Individuals who are opponents to change within an organization may result in overlooking energy efficiency measures that are cost effective.
Bounded rationality	Instead of being based on perfect information, decisions are made by rule of thumb.
Power	Low status of energy management may lead to lower priority of energy issues within organizations.
Culture	Organizations may encourage energy efficiency investments by developing a culture characterized by environmental values.
Risk	Risk aversion may be the reason why energy efficiency measures are constrained by short pay-back criteria.

3.2. ENERGY SERVICES

Energy services is a relatively new term that refers to contractual arrangements that aims at measurably improving energy efficiency.

The Swedish Energy Agency (SEA) divides energy services in two categories, indirect energy services and complex energy services. Indirect energy services are services that provide information and advice without implementing changes or technology, such as energy statistics, energy audit and energy counseling. Indirect energy services often function as pre- studies for complex energy services to execute changes. (SEA 2011)

Complex energy services include implementation of energy efficiency measures, load control, service contracts and energy service contracts for maintenance and operation. Complex energy services are sometimes offered in contracts with performance based remuneration. These contracts are called energy performance contracts (EPC) and companies that offer EPC are called energy service companies (ESCOs). (SEA 2011) Complex energy services are sometimes offered with external financing third party financing (TPF).

Energy services have been mentioned both in academic literature (Sorrell et al. 2000; Vine et al 2005, Lindgren, Nilsson 2009) and in political directives (e.g. EC 2006) as a tool to overcome many of the barriers to energy efficiency in organizations whose core business is not related to energy. Consulting ESCOs is a way for organizations to out-source energy management. They help overcoming informational barriers since ESCOs core business is energy management, their services requires them to stay well informed about technical and economical energy management solutions. Since ESCOs specialize in energy savings they have the advantage of economies of scale, they use their knowledge multiple times which reduces the cost for knowledge assimilation per KWh. TPF help overcoming capital shortages. (Vine 2005; Lindgren and Nilsson 2010; Sorrell 2007) Energy services are provided in performance based contract also reduce the risk since the ESCO share the project risk. However, consulting an external part to manage something as complex as energy management also generate costs. What an ESCO gain in scale advantage and reduced risk must compensate for the extra costs generated from transferring some or all of the responsibility for energy management to an external part. Since transaction costs are not necessarily related to the size of the contract complex energy services are more profitable in large contracts. (Vine, 2005; Lindgren and Nilsson 2010; Sorrell 2007)

In summary, energy services majorly regard support from an ESCO when it comes to investments in more energy efficient technologies, and may help overcome, among other barriers, lack of access to capital and information asymmetries and imperfections.

3.3. ENERGY MANAGEMENT

Energy management is an area of great importance when it comes to energy-end-use efficiency in industry. For an industry two major areas of energy improvements exists, supply and demand.

On the supply side, the company may either try to reduce the actual price of energy by initiating discussion with the energy company. Moreover, a company may also invest in own energy supply or deliver energy (electricity and heat) to actors outside of the company. This is common in energy-intensive industries such as iron- and steel and pulp- and paper industry, where these often both export electricity and district heating to the nearby district heating grid, coming from excess heat from the production. For the foundry industry, there is major utilizable excess heat from the melting process. However, the temperature levels are often too low to be able to deliver district heating which often demand temperatures of hot water of 100 degree Celsius or more.

Apart from the supply side actions, there is also the potential of improving the demand side by energy efficiency activities. Reducing energy costs may be done in four principal ways:

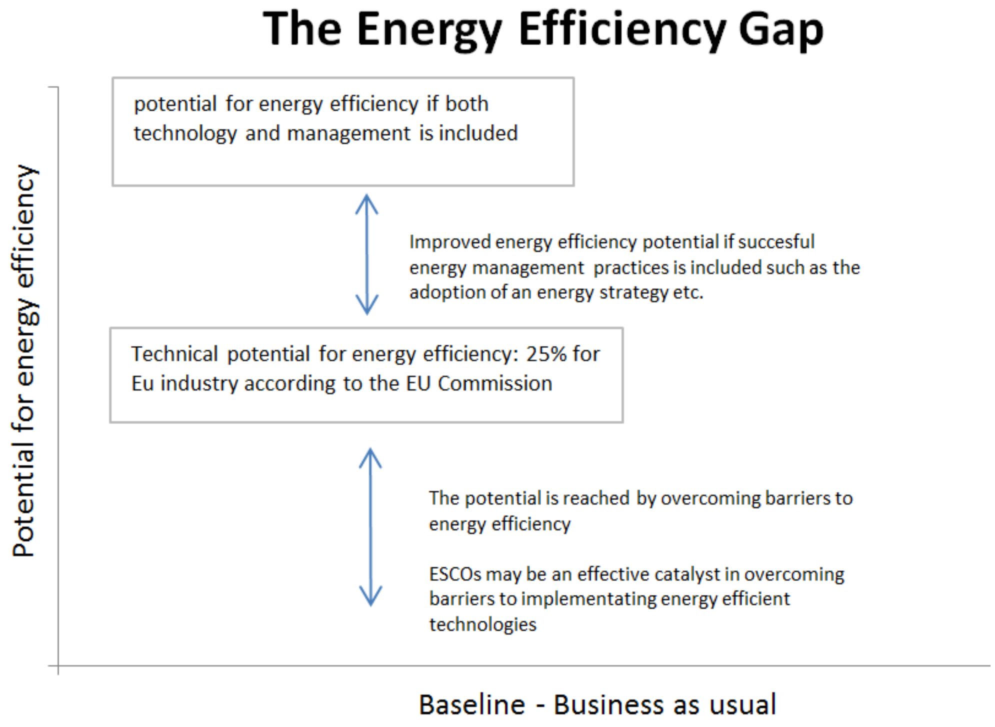
- More energy efficient technologies
- Load management
- Conversion of energy carriers
- More energy efficiency operation/behaviour

The major emphasis in terms of research and practical means is to focus on technology, i.e. the first three ways, more energy efficient technologies, Load management, and conversion of energy carriers. However, early research by the International Energy Agency state that for manufacturing industry, successful energy management it is as much about the operation and behaviour as it is regarding technology. Implicitly, one may thus be able to state that the energy efficiency potential including efficient operation and behaviour may be greatly improved. A number of important factors for successful energy management exist. Two of the more crucial are to conduct an energy audit and adopt a long-term energy strategy (Thollander et al., 2007; Thollander and Ottosson, 2010).

Energy audit: the importance of conducting an energy audit. Without knowing the energy balance and the major areas for improvements, it is like for a controller to set next year's budget without having any historical data of last year's cash flow. Such a budget at best turns out to be moderate, at worst disastrous. An energy audit may thus help overcome, among other barriers, information asymmetries and imperfections.
A long term energy strategy: With a long-term strategy, the company board of directors show that this is an area of major importance. Without a strategy the work with energy efficiency face the risk of becoming a low priority issue in the company, i.e. other areas are prioritized before. The design of a strategy may thus eliminate barriers such as split incentives.

Figure 4 presents how the inclusion of energy management practices may greatly enhance the potential for energy efficiency.

Figure 4, ***Explaining the energy efficiency gap when including the potential for successful energy management practices (Thollander, 2011).***



3.4. METHODS AND DELIMITATIONS

A questionnaire including several questions regarding key figures related to energy and production, barriers to and drivers for increased energy efficiency, energy services and energy management, among European foundries, was sent out to foundries in Finland, France, Germany, Italy, Poland, Spain and Sweden the beginning of 2011. The questionnaire was sent out in collaboration with Swerea SWECAST and collaborators in each country, either national foundry associations or research institutes. Each national collaborator sent out the questionnaire to foundries in their country, via mail or postal services. This report is concentrated on the answers regarding barriers and drivers to energy efficiency. Below table 1 is presenting which actors that were responsible for submitting the questionnaire from the different countries included in the study.

Table 2*, Partners involved in the collection of data*

Partner	**Country**
AX Consulting Ltd	Finland
Institut fuer Giessereitechnik gGmbH	Germany
Swerea SWECAST AB	Sweden
Foundry Research Institute	Poland
Centre Technique des Industries de la Fonderie	France
Inasmet-Tecnalia	Spain
Assofond	Italy
The International Meehanite Metal Co Ltd	United Kingdom

The questionnaire was sent out to 831 foundries. Due to some technical difficulties with the questionnaire program and the length of the questionnaire, only 70 answers were initially collected. Since many of the collected responses lacked important information additional facts have been added afterwards after having phoned concerned foundries and national associations. The final response rate was 125 answers, among where 65 fully answered the questionnaire. This gives an answer frequency of 8 % of full answers and 15 % including the ones which were partly answered. This quite low answer frequency naturally limits the possibility to draw general conclusions.

In Table 3 the distribution of the questionnaire sample is demonstrated. Size, output material and country of the participating foundries are visualized.

Table 3*: Overview of collected responses from the Foundry Bench project. (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

3.5. QUESTIONNAIRE DESIGN

The questionnaire design was based on previous research in the area, e.g. the questionnaire concerning barriers to energy efficiency was based on previous research conducted by Sorrell et al (2000). Sorrell et al (2000) based their designed questionnaire on barriers on an extensive review of the scientific literature on the subject. This lead to a total of 22 proposed empirical barriers to energy efficiency, see Table 4 below.

Table 4, ***Questions regarding barriers to energy efficiency***

Barrier
1 Conflicts of interest within the company?
2 Long decision chains?
3 Cost of staff replacement, retirement, retraining?
4 Dep./workers not accountable for energy costs?
5 Energy manager lack influence?
6 Uncertainty regarding the company's future?
7 Cost of production disruption/hassle/inconvenience?
8 Low priority given to energy management?
9 Lack of sub-metering?
10 Lack of staff awareness?
11 Energy objectives not integrated into operating, maintenance or purchasing procedures?
12 Technology is inappropriate at this site?
13 Lack of time or other priorities?
14 Technical risks such as risk of production disruptions?
15 Lack of technical skills?
16 Poor information quality regarding energy efficiency opportunities?
17 Lack of budget funding?
18 Slim organization?
19 Difficulties in obtaining information about the energy consumption of purchased equipment?
20 Cost of identifying opportunities, analysing cost effectiveness and tendering?
21Possible poor performance of equipment?
21 Other priorities for capital investments?
22 Access to capital?

The empirically derived questions included in the questionnaire may thus be coupled to the theoretical barriers to energy efficiency. For a more thorough description of the theoretical barriers to energy efficiency, please see chapter two.

While studies on barriers to energy efficiency is a field which has been under study for the last 20 years or more, even though extensively studied, the area of driving forces to energy efficiency is quite new. Nevertheless, previous research has found that not only cost reductions, resulting from lowered energy use are of importance. Other factors such as a committed energy manager and other factors, may also be of crucial importance. The part of the questionnaire on driving forces was initially developed in Rohdin and Thollander (2006), and later developed using a workshop in the Swedish foundry industry in 2006 (Rohdin et al. 2007).

Moreover, the scientific literature on the subject has been reviewed in, e.g. Thollander and Ottosson (2008), leading to the inclusion of yet more driving forces. The final design of the driving force part of the questionnaire is displayed in the Table 5.

Table 5, ***Drivers for energy efficiency.***

Driver
1. People with real ambition?
2. Long term energy strategy?
3. Environmental Management System (EMS)?
4. Environmental company profile?
5. Improved working conditions?
6. Cost reductions resulting from lowered energy use?
7. Network within the company/group?
8. Threat of rising energy prices?
9. International competition?
10. European Emission Trading Scheme (EU ETS)?
11. Energy tax?
12. Sulphur tax?
13. NO_x tax?
14. CO_2 tax?
15. General energy advices through seminars?
16. General energy advices through journals/booklets?
17. Electricity Certificate System (ECS)?
18. Voluntary agreements with tax exemption (PFE)?
19. Energy efficiency requirements due to national environmental codes by governmental administration?
20. The public sector as a role- model?
21. Your municipality being part of an energy/climate efficiency program?
22. Network within the sector?
23. Information and support through the sector organization?
24. Beneficial loans for energy efficiency investments?
25. Pressure from different environmental NGOs?
26. ESCOs responsible for operation and maintenance of the buildings?
27. Annual environmental report to public administrations?
28. Commitment from top management?
29. Local authority energy consultancy?
30. Demand from owner?
31. Customer questions and demands?
32. Investment subsidies for energy efficiency technologies?

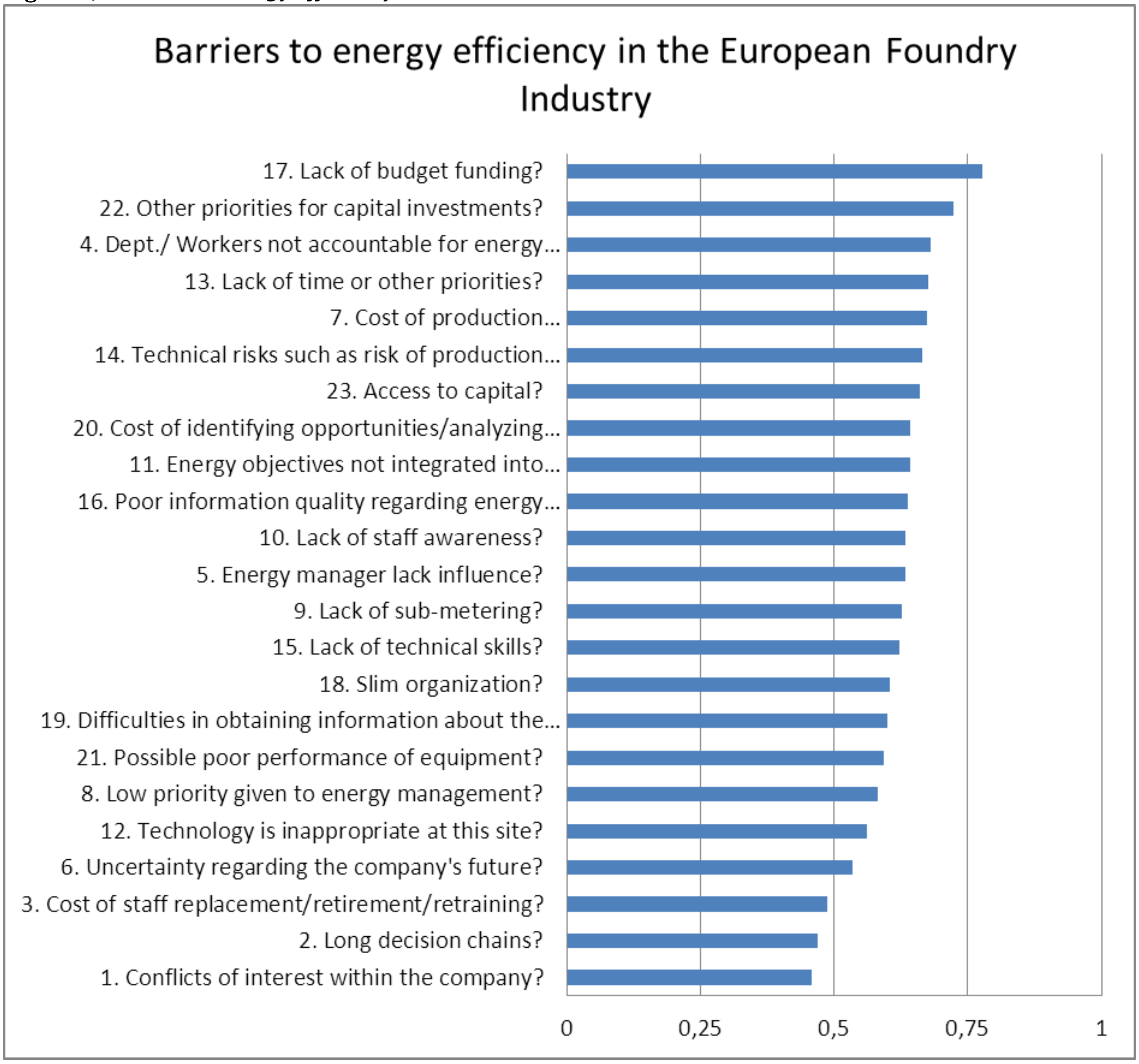
4. RESULTS

This part of the report presents the major findings from the questionnaire beginning with presenting the major barriers, followed by the driving forces. Finally, results from the questionnaire including questions on management and energy service are outlined.

4.1. BARRIERS TO ENERGY EFFICIENCY

The respondents 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 respondents' answers of listed barriers can be found inTable 4. The answering alternatives were "no impact" "almost no impact" "neutral" "some impact" and "major impact". The answering alternatives were quantified between 0 and 1, 0 meaning no impact and 1 meaning major impact and the results are presented in Figure 5.

Figure 5, *Barriers to energy efficiency*



As in the study of the Swedish foundry industry in 2005 lack of budget funding is ranked as the most important barrier to energy efficiency (Rohdin et al., 2007). Other barriers such as other priorities for capital investments, department/workers not accountable for energy costs, lack of time and other priorities, are also perceived as having high impact.

Only three of the questions got a mean below 0.5, which means that they were not ranked as having an impact on energy efficiency: cost of staff replacement, retirement, retraining, conflicts of interest within the company, and long decision chains.

Comparing these findings with similar studies of other sectors apart from the foundry industry reveals that the barriers in the European foundry industry have special characteristics, i.e. are not fully the same as barriers in the brewing industry in the UK or German SMEs (Sorrell et al. 2004; Schleich and Gruber, 2008).

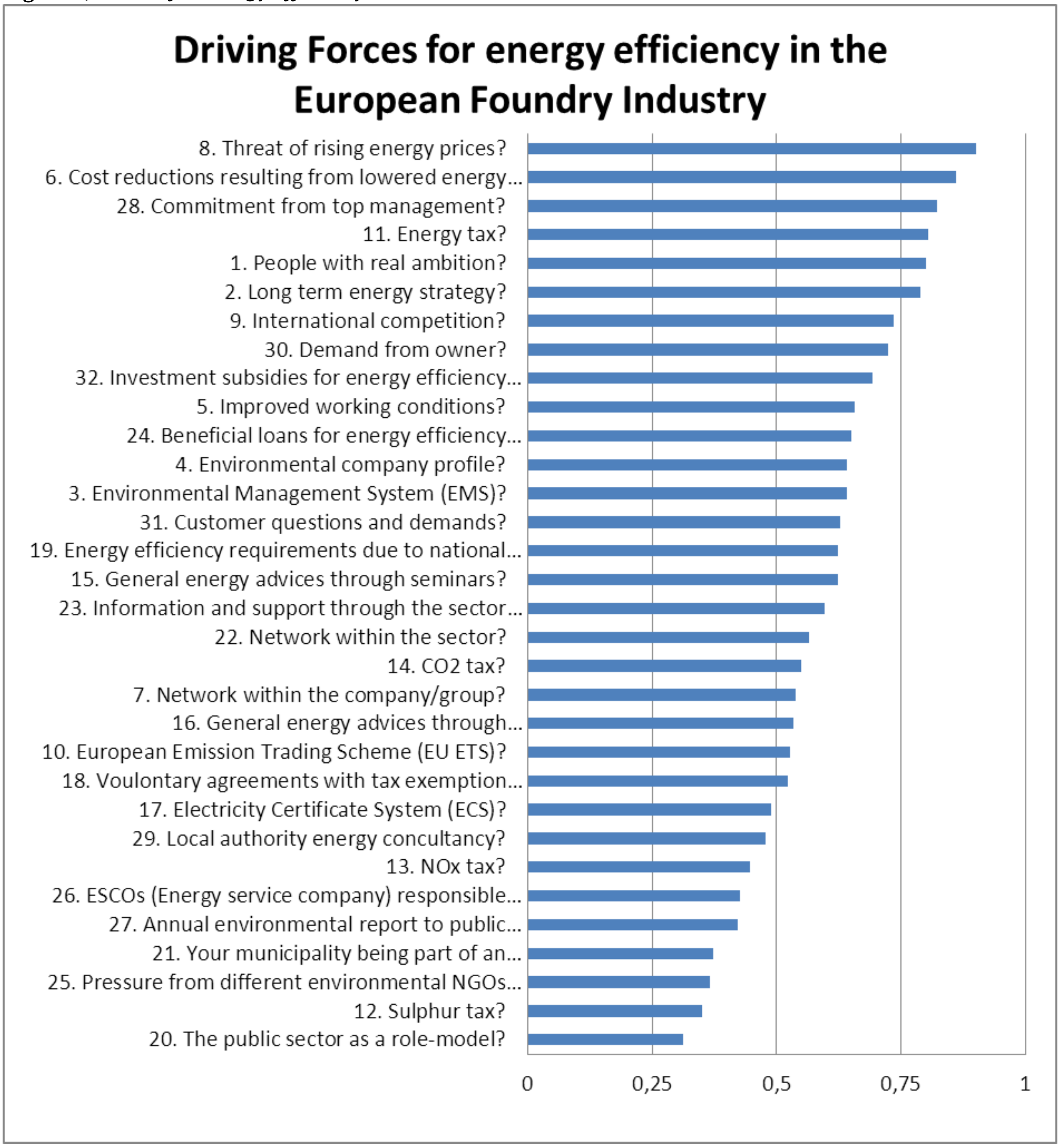
4.2. DRIVERS FOR ENERGY EFFICIENCY

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 respondents' answers of listed drivers can be found in Table 5. The answering alternatives were "no impact" "almost no impact" "neutral" "some impact" and "major impact".

The answering alternatives were, as for the question regarding barriers, quantified between 0 and 1. 0 meaning no impact and 1 meaning major impact and the results are presented in Figure 6.

The two highest listed drivers are economic factors, threat of rising energy prices and cost reductions resulting from lowered energy use, two sides of the same coin since the savings from energy efficiency become larger as the price of energy increases. The public sector as a role model, pressure from environmental Non-governmental organizations (NGO's), local municipalities' engagement in energy management projects, annual environmental report to public administrations, ESCOs responsible for operation and maintenance of the buildings, are ranked as having almost no impact on the implementation of cost-effective energy efficiency measures, as well as NOx- and sulphur taxes.

Figure 6, ***Drivers for energy efficiency***



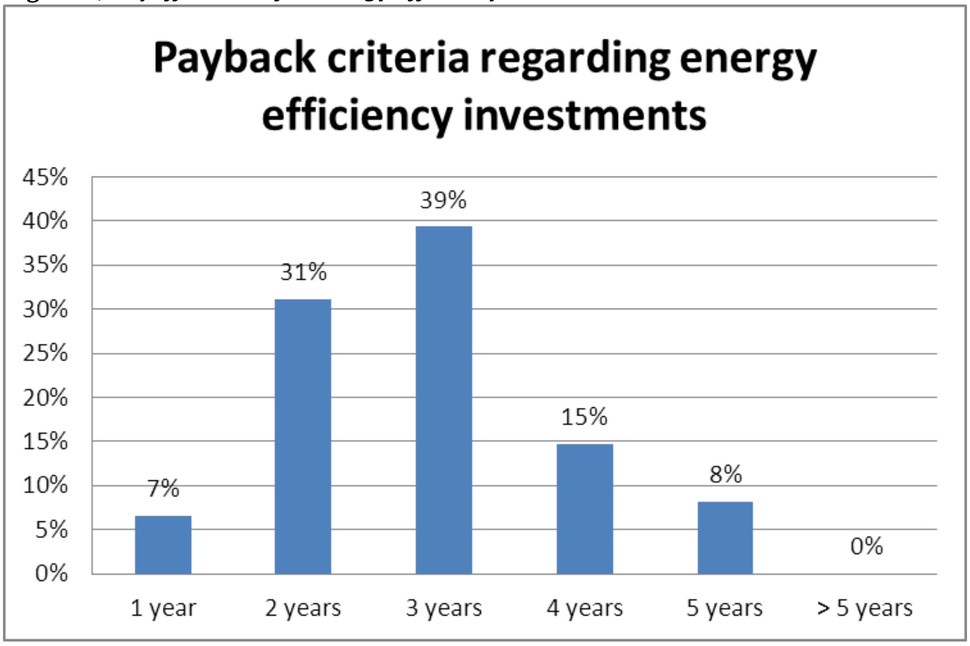
Comparing these findings with other studies on drivers for energy efficiency reveals that there are a number of common high-ranked drivers such as threat of rising energy prices, a long-term energy strategy, people with real ambition, commitment from top management, and cost reductions resulting from lowered energy use (Thollander and Ottosson, 2008; Thollander et al., 2009). Notably, these findings reveal the importance of energy management adoption according to the respondents. Moreover, while the barrier part shows that barriers differs between industries, the driving force part reveals that some major drivers seems to be similar in different industries.

4.3. ENERGY MANAGEMENT PRACTICES AND ENERGY SERVICES

4.3.1. 4.3.1 The pay-back criteria among foundries

Several ways of improving energy efficiency investments exist, one of the most recognized and straightforward methods being the pay-off method. The so called principal-agent relationship barrier may sometimes be manifested in the form of strict investment criteria, i.e. short pay-back periods. Results are outlined in Figure 7 below.

Figure 7, ***Payoff-criteria for energy efficiency investments***



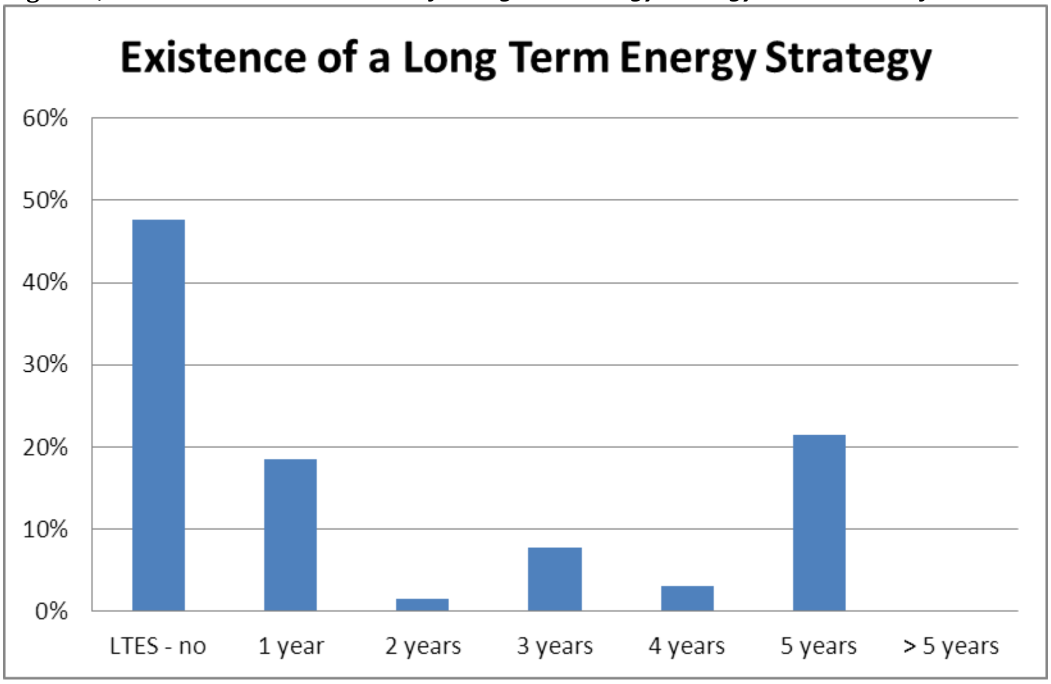
Notably, 77 % of the studied foundries have payoff criteria of three years or less with the most common criteria, three years comprising 39 % of the foundries.

Moreover, the foundry respondents rank lack of budget funding as the major barrier to energy efficiency followed by other priorities for capital investments. Improving the adoption rates for energy services in the European foundry industry thus seems to have a great potential for improving energy efficiency.

4.3.2. The existence and duration of a long-term energy strategy

Previous research has shown that a long-term energy strategy is one of the highest ranked factors promoting energy efficiency in industry (Rohdin and Thollander, 2006, Rohdin et al., 2007, Thollander and Ottosson, 2008, Thollander and Ottosson, 2010). Figure 8 shows the existence/non-existence and the duration of a long-term energy strategy among the studied foundries.

Figure 8, ***The existence and duration of a long-term energy strategy at the studied foundries***



Notably, nearly half of the studied foundries lack a long-term energy strategy. This outlines a large potential/lack of interest in regard to in-house energy management practices. Notably, this response is not endemically related to foundries. Thollander and Ottosson (2010) found that a large part of the Swedish pulp- and paper mills, nearly half, either lacked a long-term energy strategy or had a strategy less than three years. Notably, the foundry respondents rank this as the sixth most important driver for energy efficiency. This may reveal that company board of directors do not give the issue of energy efficiency a high priority within the company. It may also be an effect of the fact that owners of the foundry, in some cases the stock market, does not point this out as an area which provides any major value-adding part to their company.

In conclusion, this finding that nearly half of the European foundries lacks an energy strategy show a major area for improving energy efficiency through the adoption of successful energy management practices in the European foundry industry.

4.3.3. The use of EPC (Energy Performance Contracting)

The use of energy services like EPC (Energy Performance Contracting) is outlined as one of the major promising areas for energy efficiency improvements in industry according to the European Commission in the Energy End-Use and Energy-Services Directive (2006) (EC, 2006). In the questionnaire it was found that 15 foundries had used EPC. From the sample of full answers, this gives a rate of 23 %. Figure 9 displays the use of EPC among the studied foundries.

Figure 9, ***The use of EPC among the studied foundries***

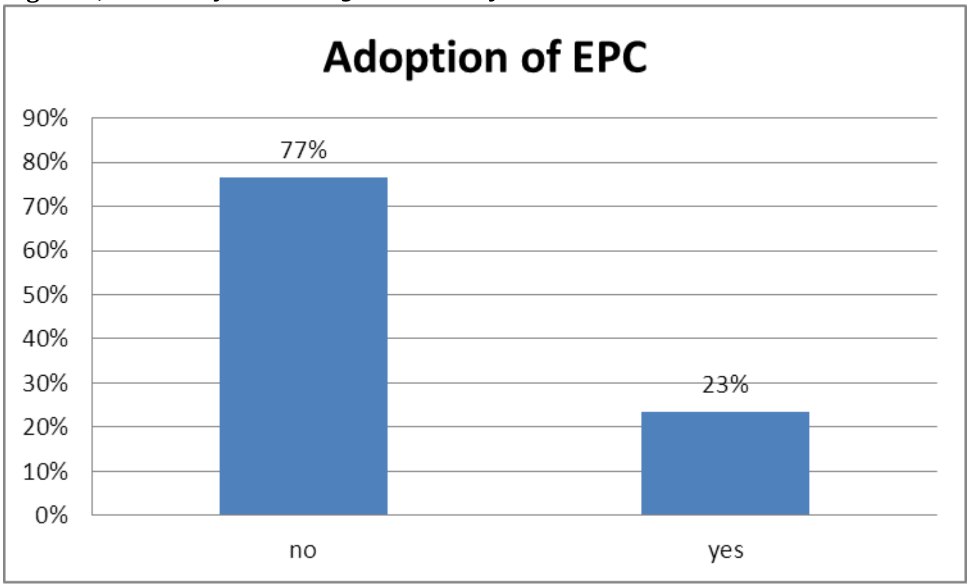


Figure 9 outlines that there are still a considerable number of foundries that have not used EPC at their site. The reason for non take-up of EPC could be explained by, e.g. high transaction costs for energy services (Backlund and Thollander, 2010). Transaction costs are not the cost of implementation but the cost related to realize a transaction and a contract. The term include search costs, legal costs etc. and they are not necessarily related to the size of the contract, at least not in terms of kWh. Since the EPC contracts tend to be complex, transaction costs can be large in relation to the total gains from saving potentials.

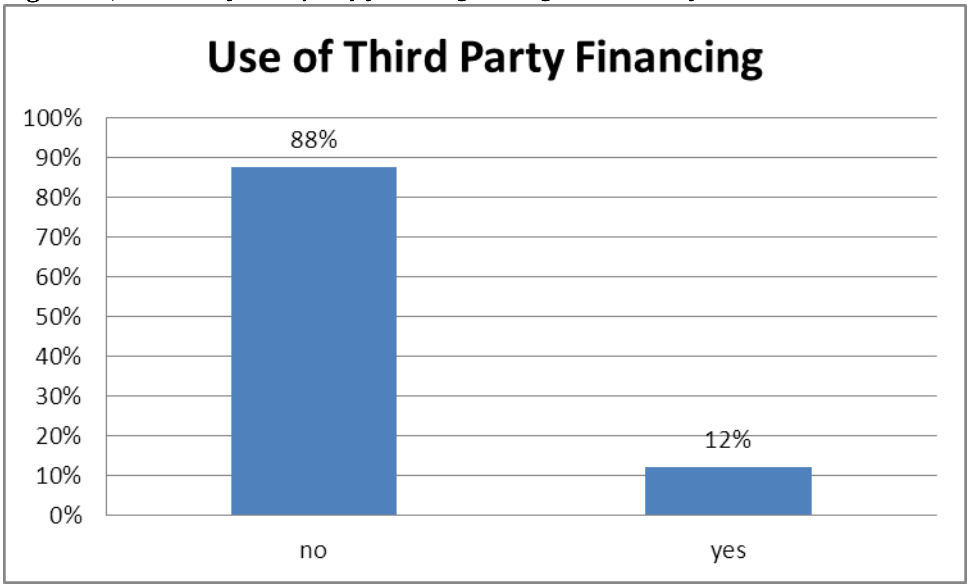
Notably, the foundry respondents rank lack of budget funding as the major barrier to energy efficiency and EPC is successful means in carrying out investments without affecting of the company budget.

In conclusion, this finding that about three quarters of the European foundries have not used EPC show a major area for improving energy efficiency through the adoption of energy services in the European foundry industry.

4.3.4. The use of Third Party Financing

Together with EPC, the use of energy services like third party financing is outlined as one of the major promising areas for energy efficiency improvements in industry according to the European Commission in the Energy End-Use and Energy-Services Directive (2006) (EC, 2006). In the questionnaire it was found that 8 foundries had used third party financing. From the sample of full answers, this gives a rate of 12 %. Figure 10 displays the use of third party financing among the studied foundries.

Figure 10, ***The use of third party financing among the studied foundries***



Alike the results regarding EPC, Figure 10 outlines that there is still a considerable number of foundries which have not used third party financing at their site. The reason for non take-up of third party financing could be explained by, e.g. high transaction costs for energy services (Backlund and Thollander, 2010), but is an area which is suggested to be included within future research projects within the EU. Half of those who have used third party financing have also used EPC.

Notably, the foundry respondents rank lack of budget funding as the major barrier to energy efficiency and EPC is successful means in carrying out investments without affecting of the company budget.

In conclusion, this finding that about 90 percent of the European foundries has not used Third Party Financing show a major area for improving energy efficiency through the adoption of energy services in the European foundry industry.

4.3.5. Energy audits among foundries

Together with other energy services like the previously outlined EPC, energy auditing is outlined as one of the major promising areas for energy efficiency improvements in industry according to the European Commission in the Energy End-Use and Energy-Services Directive (2006) (EC, 2006). While EPC and Third Party Financing is related to financing and implementing already detected technical improvement measures, an energy audit is majorly carried out in order to detect measures. In the questionnaire it was found that 38 foundries had carried out an energy audit. From the sample of full answers, this gives a rate of 58 %. Figure 11 displays if the foundries have conducted an energy audit or not.

Figure 11, ***The number of foundries which have conducted an energy audit.***

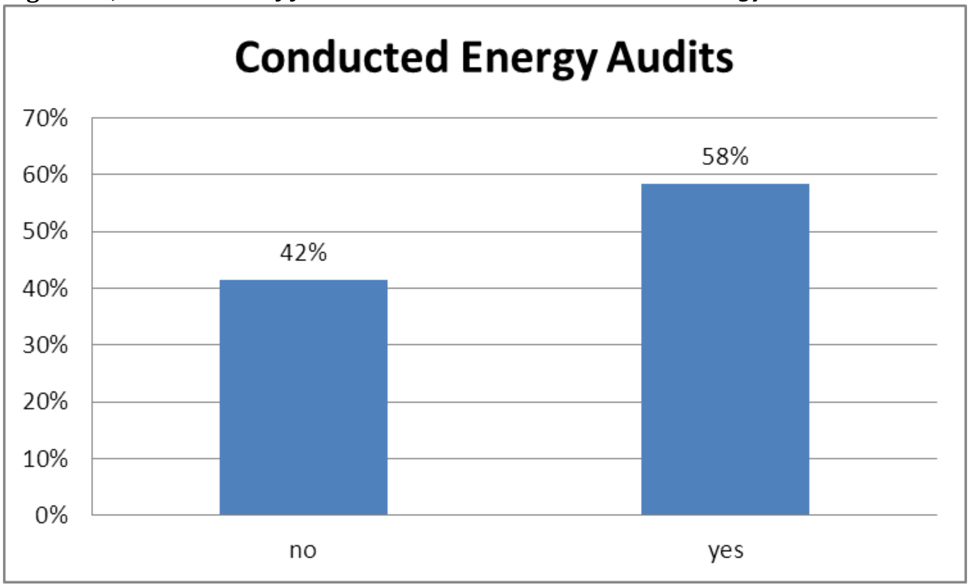


Table 6Table 1 displays the use of energy audits among the studied countries' foundry industries.

Table 6, ***The use of energy audits among the studied country's foundry industries.***

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%

As Table 6 displays, there is a large difference between the different countries where Germany followed by Sweden shows the largest adoption/use of energy audits. 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 (Gruber and Brand, 1990).

In conclusion, this finding that about 60 percent of the European foundries have not conducted an energy audit show a major area for improving energy efficiency.

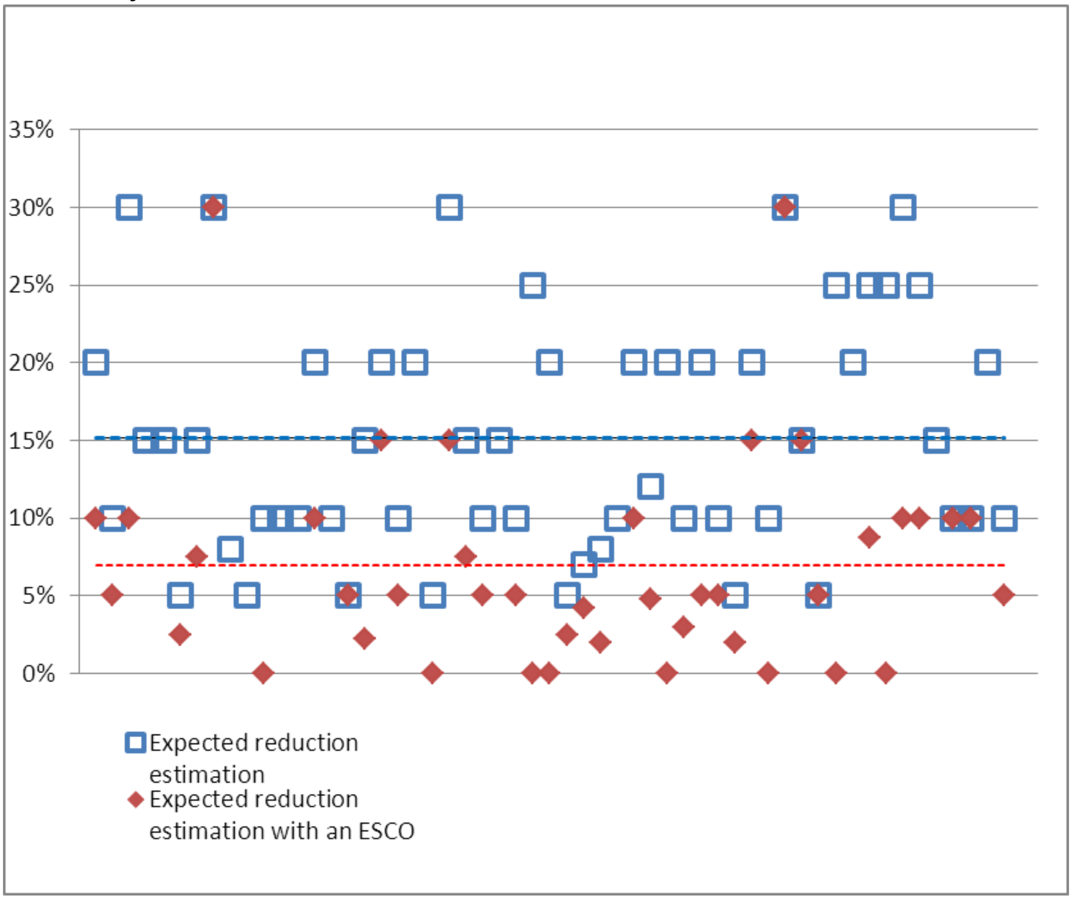
4.3.6. The expected potential for energy savings

The energy efficiency potential for the European industry is 25 % according to the European Commission in its 2020 Primary Energy roadmap, the major improvements being found among the support processes according to the roadmap (EC, 2006b). In regard to more energy-intensive industries like the foundry industry, it must be noted that the percentage of support processes are relatively lower than in non-energy intensive companies, this due to a large use of energy in the production process. The aggregated answers from the foundries were that a potential for energy efficiency improvements of 15 % exists.

4.3.7. How much of the energy efficiency potential could be deployed consulting an ESCO

In order to implement energy efficiency measures in industry, an ESCO providing energy services like energy audits, EPC and third party financing could be a means to deploy the energy efficiency potential. The aggregated answers from the foundries were that about 45% of the energy efficiency potential is stated to be able to be reduced by consulting an ESCO. This result provides clear evidence that an ESCO could indeed take a company a long way in order to improve energy efficiency levels. However, this also points out the need for internal energy management practices in order to fully deploy the potential, as also stated in Figure 4. This later finding has to the author’s knowledge never been proved in any previous research of energy efficiency in industry. For those who have already been consulting an ESCO, the percentage is 54%. The very same percentage was found for those who have an energy strategy of three years or more. The results are outlined in Figure 12.

Figure 12, ***Aggregated energy efficiency potential and expected deployment levels from consulting an ESCO, among the studied foundries.***



As shown in Figure 12, consulting an ESCO will according to the studied foundries result in an improvement in energy efficiency of, in average, 7 %.

5. CONCLUDING DISCUSSION

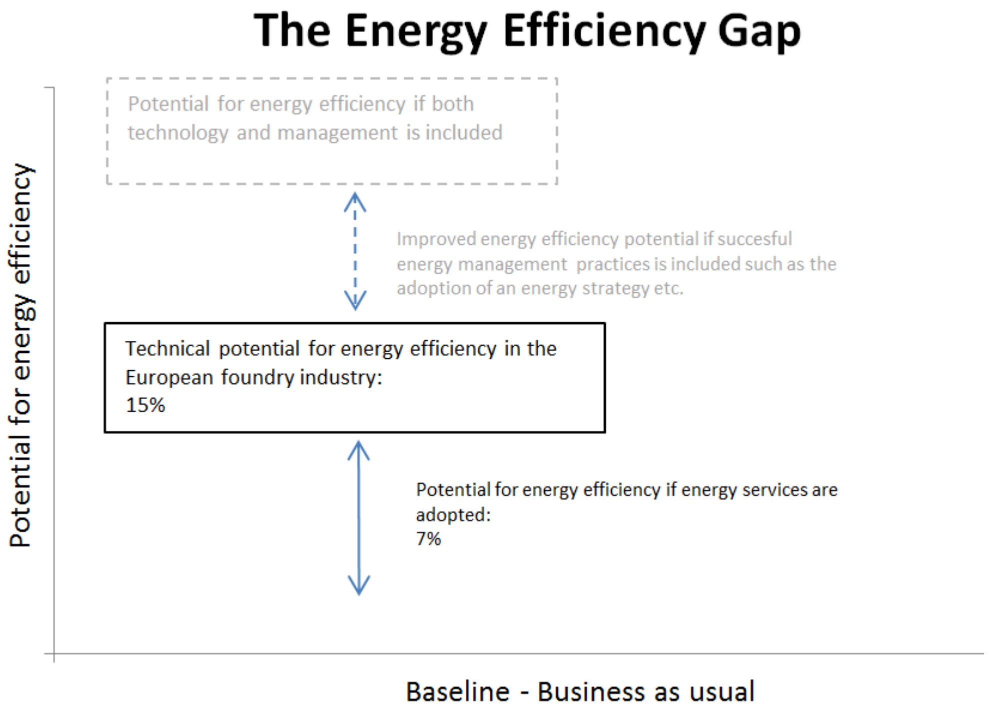
Increasing energy prices in Europe have raised the awareness of the importance of energy efficiency. Energy conservation has become significant not only for environmental reasons but also for economic reasons and to remain competitive. The foundry industry has an energy intensive production and therefore 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 aim of this study is to i) study factors which promote and inhibits energy efficiency, and ii) study the degree of implementation of a variety of energy services and in-house energy management practices, in the European foundry industry.

This report presents the results from a questionnaire conducted in 2011 regarding barriers to and drivers to energy efficiency, energy services and energy management practices 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. These results are congruent with the findings in similar studies about barriers and drivers to energy efficiency in industry. (Thollander 2008, Rohdin and Thollander 2005)

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 (39 %).

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 13 show the stated potential for energy efficiency in the European foundry industry as well as the potential for energy services.

Figure 13, ***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.

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