Energy services in industry – an interdisciplinary approach with engineering and social science aspects

P. Thollander[1], J. Palm[1], T. Sakao[1]
Linköping University, SE-581 83 Linköping, Sweden
patrik.thollander@liu.se, jenny.palm@liu.se, tomohiko.sakao@liu.se

Abstract
A large potential for energy efficiency exists in industry but the adoption of energy efficiency measures is often inhibited by various barriers. Different means to overcome these barriers and promote energy efficiency in industry exist, one of the most promising being energy services. Earlier research shows that while many barriers could be overcome by energy services, the industry's ranking and adoption of energy services are very low. By applying an interdisciplinary approach using barrier theory, socio-technical regimes, and IPSE (Integrated Product Service Engineering) to energy services in industry, the aim of this paper is to i) theoretically explain why there is a considerable discrepancy between the potential for energy services in industry and their adoption, and ii), partly based on i) and by applying an interdisciplinary approach, attempt to explore ways of reaching a satisfactory level of energy services in industry.

Keywords
Energy efficiency, services in manufacturing industry, barrier theory

1 INTRODUCTION

One of the major means of reducing emissions of greenhouse gases (GHG) is to increase industrial energy efficiency. A recent report by the IEA (International Energy Agency) stated that even from the most "technology-optimistic" perspective, industrial energy use will increase over the next 50 years [1]. The European Union, working proactively to increase energy efficiency and reduce GHG emissions, states in a directive on energy efficiency that the Member States shall aim to reduce their use of energy within the coming nine years by nine percent through eliminating barriers to energy efficiency [2].

Saving energy is at the same time often a part of customer value. Energy services have the potential to contribute to decrease energy use and thus add customer value. The above-mentioned EU directive indeed states that the EU, through each Member State, should develop the energy services markets and investigate, for example, third party financing. Tackling energy saving can be a practical research issue within research on Industrial Product Service Systems (IPS[2]), which are defined as "an integrated industrial product and service offering that delivers value in use" [3].

By applying an interdisciplinary approach using barrier theory, socio-technical regimes, and IPSE (Integrated Product Service Engineering) [4] to energy services in industry, the aim of this paper is to i) theoretically explain why there is a considerable discrepancy between the potential for energy services in industry and their adoption, and ii), partly based on i) and by applying an interdisciplinary approach, attempt to explore means to reach a satisfactory level of energy services in industry. The paper's scope is energy services in the non energy-intensive and small and medium-sized manufacturing industry, i.e. it does not address energy services in energy-intensive industry. The paper is unique in the sense that it explores the timing topic – increased industrial energy efficiency through the adoption of energy services – applying an interdisciplinary approach.

The primary method applied in this paper is literature analysis. Section 2 reveals the current status of energy services including the fact that the degree of energy service adoption in Swedish small- and medium-sized and non-energy-intensive industry is considerably low [5, 6]. Section 3 introduces existing theoretical insights, and Section 4 derives some results of the literature analysis. Section 5 provides discussion pointing out the need of empirical research.

2 STATUS QUO OF ENERGY SERVICES

Recent research on barriers to energy efficiency in Swedish industry has found that lack of access to capital and lack of budget funding were among the top-ranked barriers [7]. Third party financing and energy performance contracting are means to enhance energy efficiency and overcome, for example, financial barriers [8].

Unlike energy-intensive industries, where energy efficiency measures mainly concern the production processes, energy efficiency measures in non-energy-intensive and small and medium-sized manufacturing industries are related mainly to support processes [7]. HVAC, compressed air, lighting and tap hot water are normally categorized among the support processes [9]. ESCOs mainly orient their businesses towards the support processes and thus seem to be suitable when it comes to overcoming barriers to energy efficiency in the non-energy-intensive manufacturing industry.

Evaluations of Swedish industrial energy programmes have revealed that the support processes contribute to about half of the cost-effective energy savings undertaken by energy-intensive industries, and close to 90% among non-energy-intensive and small and medium-sized industries [10]. According to [11], on average only 15% of the measures that are profitable for property owners are implemented, a picture that is repeated in the industrial and transport sectors. Consequently, if energy services for Swedish industry are to be developed further, there is great potential not only for reduced emissions of CO2 and reduced industrial energy use but also new business opportunities.

Increased industrial energy efficiency through energy services has a positive impact on the reduction of GHG. The scarcity of the use and development of, and research on energy services in industry, and the great potential for energy efficiency through energy services calls for research in this area. The Swedish Government Bill for example states a potential annual energy saving figure of 2-3 TWh through more efficient use of energy in small and medium-sized industries [12]. Other figures state a 20% energy efficiency potential in small and medium-sized industries and non-energy-intensive industry in the EU [13]. The Swedish ESCO market has hitherto primarily involved customers in the public sector focusing on control systems, ventilation and heat recovery [14] while the ESCO market for industry is considerably underdeveloped. Geissler et al. [15], for example, estimate the energy-saving potential through ESCOs to be around 15% of the present Swedish energy demand.

It is an intricate matter to give a potential figure of how much energy can be saved in such an early stage of business model development. However, based on related research such as [9] one may conclude that the potential is vast. Moreover, the stated potential of 2-3 TWh annually, relates to measures available with strict investment criteria. Energy performance contracting and third party financing enable investments with much longer payoff-periods, which means that the potential for energy services is far greater. From an annual energy usage of about 40-45 TWh among Swedish small and medium-sized industries and non-energy-intensive manufacturing industries, a simple calculation reveals that if energy services were to achieve only 10% of the energy efficiency potential of 15% according to [15], annual savings of 600 GWh per year or more would be reached.

However, while energy services are an important means to reduce barriers to energy efficiency, it has not been extensively studied among Swedish industries. Also, traditional industrial energy efficiency research has emphasised technical matters – such as, for example, the energy efficiency potential from implementing specific technologies [9]. The use and adoption of energy services still very much needs to be further explored. While the lack of industrial energy efficiency research related to energy services in a Swedish and an international context remains, the environment demands fast action. Moreover, Swedish industry has been faced with substantial energy price increases in recent years, creating problems in particular for energy-intensive industries as many Swedish industries use more electricity than their European competitors. Furthermore, the current economic turbulence requires Swedish industry to spot potential areas for cost reductions in order to survive. Research related to energy services demands an interdisciplinary approach, involving both technical and social science issues, calling for an interdisciplinary study on the issue. Although the earlier activities directed towards the public sector in Sweden have brought progress in the field [14], great potential still exists to increase energy efficiency in industry [15]. Consequently, if energy services for Swedish industry are to be further developed, there is potential not only for reduced energy efficiency and lower emissions of GHG but also increased business activity.

3 THEORETICAL APPROACH

3.1 Barriers to and driving forces for energy efficiency

Energy efficient technologies are not always adopted, which is explained by various barriers to energy efficiency. This discrepancy between energy efficiency potential and actual implementation results is called the energy efficiency gap. A barrier is defined as 'a postulated mechanism that inhibits investments in technologies that are both energy-efficient and economically efficient' [16]. A driving force may be defined as the opposite of a barrier, i.e. a factor which promotes investments in technologies that are both energy-efficient and cost-effective [17]. The most often cited barriers include heterogeneity, lack of access to capital, hidden costs, risk, and imperfect and asymmetric information [18]. Empirical studies on barriers to and driving forces for energy efficiency in industry show a considerable discrepancy between the barriers identified and the driving forces. Thollander [7] and Thollander et al. [19] show that while many of the barriers, for example lack of time and other priorities and lack of access to capital, could be overcome by various energy services such as energy performance contracting, third party financing etc., the industry does not in fact rank such means particularly high.

The energy efficiency gap is based upon the hypothesis that there exists a technology, method or process that leads to reduced use of energy in industry, but due to the existence of various barriers to energy efficiency, this technology or method is not implemented. If the actors were to act in a rational way this energy efficiency gap would not exist. In reality, however, it does exist and different kinds of barriers to energy efficiency have been identified to explain it. The barriers are many and include risk and lack of information, knowledge, time or access to capital. One criticism of this barrier approach, however, is that it leads to reductionism in research (compare [20]. Taking an STS (Science, Technology & Society) approach, the energy efficiency gap can be understood better in a social and institutional context, which will be discussed next.

3.2 Energy efficiency in the perspective of socio-technical regimes

The paper is interested in how socio-technical changes occur in industries and how and why energy efficient solutions are - or are not - implemented. Several approaches deal with these issues from different perspectives and starting points. The transition management approach aims to support the emergence of sustainable technological alternatives by analyzing social, infrastructural and institutional systems as driving forces for or barriers to technological change [21]. Many studies rely on terms of technological regimes [22] that they use to explain regularities in technical change. A technical regime is all the formal and informal rules that are embedded in a technology or mode of manufacturing, that structure the activities of engineers and the policies that are developed [23]. Geels [24] has developed this model and introduced the term 'socio-technical regimes', because a regime includes more actors than just the engineers. But it is on the socio-technical regime that the search must focus to explain changes to or the preservation of existing routines and why new technologies are implemented or not. A regime is relatively stable with incremental changes. Thoresson and Glad [25] have discussed socio-technical regimes in housing companies and concluded that different regimes can exist at different levels in the same company: on the board, in the planning unit and on the operational level.

Focusing energy efficient technology development in industry in the perspective of competing socio-technical regimes could throw new light on why energy efficient technology is not implemented, even if it seems both economically and technologically rational for the industry to do so. If one follows traditional STS science such as [26] and [27], Shove [28] then points out that decisions concerning how we use energy and energy efficiency measures are made in social contexts. According to Shove, practitioners identify and make energy-related decisions within different networks and different contexts: what qualifies as a reliable, cost effective, worthwhile energy saving measure in one socio-cultural domain might count for nothing in another [28]. In this perspective, energy efficiency is also dependent on social relations and discussion, negotiations and agreements developed within regimes. Experience, routines and habits established and negotiated in a regime will then decide what energy efficiency measures will be implemented. These negotiated agreements can then constitute both possibilities for and constraints to future development in each sector [29].

If we add that an industrial company can include different regimes with slightly different problem definitions, goals, routines, values and so on, then the discussion on barriers to energy efficiency and the adoption of energy services can be developed further. We have seen in earlier research that an investment which an energy manager at a company is willing to do, can be stopped by the financial administration because they have different value systems and perhaps require strict investment criteria. From interviews it has been found that the possibilities to receive approval for an energy efficiency measure are higher at the beginning of the year than at the end and the reason is not always obvious to the people in charge of energy efficiency [30].

If one looks at this in terms of socio-technical regimes, then some regimes are embedded more robustly than others, and enjoy greater institutional support and have stronger financial significance and broader legitimacy in the company. This could be an important explanation of why energy efficiency measures, known and profitable to the company, are not implemented. Studying energy services could thus benefit from in-depth studies in industry to see how employees talk about energy efficiency, and how they relate this to economic and environmental aspects. Moreover, such a study could also determine whether there are different regimes at the company and power relations between different regimes and how they influence energy efficiency and the adoption of energy services.

Identifying and addressing powerful socio-technical regimes provides an opportunity to develop new business ideas. In this perspective, a new procedure for how energy service processes should be adopted in industries is needed, where for example different regimes might need to be targeted slightly differently, even if the mission is kept unchanged.

3.3 IPSE

Energy efficiency in general is determined primarily by a used technology and a physical product implementing the technology. However, there are two other main factors with a broadened perspective. One is how the machine is operated. This is influenced by services from product suppliers or third party service providers, as well as by operation by the users themselves. Energy service is closely related to in-house energy management. Either energy management is carried out by the company or, e.g. the management of the energy issue is outsourced to a third party. Research on energy management states that savings in the magnitude of 40 % or more can be achieved [31].,This is done by a combination of

Table 1: Implications for designing energy services based on the barrier theory
(See [16] for an outline of barrier theory.)

Perspective	**Barrier**	**Implication for energy services**
Economic	Heterogeneity	- This barrier may be effectively avoided by having successfully adopted cases to rely upon and skilled ESCO staff.
	Hidden costs	- Having an ESCO involved in the initial phase of an energy efficiency investment may greatly reduce hidden costs as the ESCO staff are specialists in their field and know where to find information etc.
	Access to capital	- An ESCO providing third party financing enables this barrier to be fully eliminated.
	Risk	- The industry's risk may be considerably reduced by having "specialists" involved, which greatly enhances the investment's stability. The industry's risk of entering into a business agreement with the ESCO and vice versa, however, is not as easily reduced, calling for a complex agreement to be set up which in turn may increase the magnitude of the hidden cost barriers.
	Imperfect information	- Service opportunities exist where the information for customers/users is imperfect. - Providing information of energy consumption for economically efficient decisions may contribute to service provision. - Keeping information on how to increase energy efficiency within a provider may turn out to be a source of services.
	Asymmetric information	- Building up an agent responsible for both costs and benefits may be a key to introduce energy efficient solutions (Split incentives).
		- Visualizing and guaranteeing quality of products/services may lead to purchase of better solutions (Adverse selection).
		- Transferring (and/or translating) the information at the agent level up to the principal level may be effective (Principal-agent relationships).
Behavioural	Bounded rationality	- Routines and everyday activities do not support energy efficiency. Establish routines that contribute to 'right' decisions being embedded in everyday practices.
	Form of information	- Different regimes within a company need different kinds of information and information packages that relate to their needs and demands.
	Credibility and trust	- The industry's perception of ESCOs needs to be strong as regards their credibility and trust if an energy service is to be carried out.
	Values and Inertia	- Different value systems can exist in a company. Promote and support value systems that benefit energy efficiency.
Organisation theory	Power	- Identify different power arenas in a company to know where to target different kinds of information and measures.
	Culture	- Embedded knowledge and routines need to be identified to initiate reflection on how to change and improve them.

technology and management (services), where the latter can be addressed by IPSE and be related to the socio-technical regime as introduced in the previous section.

The reason why this type of service is valid is that the information about products is asymmetrical between users and service providers (original manufacturers or service providers). When users purchase services, they actually find it rational to pay money for benefiting from a kind of knowledge that they otherwise would not gain. This type of knowledge originates with manufacturers. Manufacturers can make use of their own knowledge to package an IPSO (Integrated Product Service Offering) [4]. In addition, other companies independent of original manufacturers can provide such services (ESCOs in this case). Thus, the issue of energy service is a good practical target in the IPSE research.

4 RESULTS FROM ANALYSES

4.1 The barrier approach

Heterogeneity, lack of access to capital and hidden costs refer to a technology involved in an energy service contract and its associated costs. From an energy efficiency perspective, there are a wide range of energy efficiency measures available with fairly low pay-off periods. However, in some cases a technology may not be able to fit into a specific production-condition due to constraints in the technology. It is either fit or not fit. No major “maybe” cases exist. In empiric research on barriers to energy efficiency, the heterogeneity barrier has been shown to be of minor importance [16], indicating that the heterogeneity barriers do not give a plausible explanation for the low adoption of energy services in industry. As regards lack of access to capital and hidden costs, these barriers may also be categorized as existent or not: either the company has access to capital or it does not. Sometimes this is self-imposed from restrictions on lending money etc. However, it may not be argued to be non-existent if the industry states that this is a barrier. The lack of access to capital barrier has been shown to be of major importance in some sectors [10, 17, 32]. The costs (hidden) associated with investments in a certain energy efficient technology may also be considered real. The hidden cost barrier has also been shown to differ between sectors [10, 17, 32]. However, applying socio-technical-regimes on the lack of access to capital and hidden cost barriers may reveal new insight on the issue and problematize how and why actors in negotiations in decision processes do not prioritize energy efficient investments even if it would be beneficial in the long run.

Risk, imperfect and asymmetric information etc. are barriers which refer to information involved in the transaction when investing in an energy efficient technology. Unlike the previously outlined barriers, these barriers also concern the actors, i.e. socio-technical regimes involved in the investment and the actor’s perception of the information regarding the investment, the information type, etc. These barriers are not related solely to technological facts, but do also include how actors perceive risks, for example associated with an investment. Various types of risk exist, for example risk of production disruption, hassle and inconvenience – a high-ranked barrier in many empiric studies on barriers. How the actors perceive the risks is connected to tradition, values and experience from past decisions and this needs to be investigated further to understand its impact on risk calculations made. Previous research has found that in some cases values, culture and power are factors which may influence decisions on energy efficiency in a positive way [6]. The credibility of and trust in a third party, such as an energy auditor, have also been shown to be crucial in the uptake (or not) of information on energy efficiency opportunities [5].

4.2 Promotion of energy services

Table 1 shows findings from the analysis of energy services using barrier theory. They include implications for energy services based on an extensive review of barriers to energy efficiency by [16]. Based on this extensive review, it is theoretically possible to derive various kinds of measures to tackle the barriers.

Apart from the outlined means in Table 1, concerning the industry and the ESCO, one may also consider promoting energy services activity by adopting public policy instruments such as risk-free state loans. Such a policy would considerably reduce the risk to both parties from entering into a business agreement. The risk barrier may also need market guidelines and principles to be set up by the Government, for example, standardized guidelines for how agreements should be set up. Such guideline would also contribute to lower the hidden cost and credibility and trust barriers and possibly also imperfect and asymmetric information barriers, as both parties would be fully informed of how an agreement should be formulated. Moreover, it is suggested that the Swedish Energy Agency sets up a separate homepage regarding energy services in industry presenting, among other things, successful examples of energy service adoption in industry. A homepage regarding energy services in industry would enable a reduction in magnitude of basically all barriers to energy efficiency in industry outlined in Table 1.

5 CONCLUDING DISCUSSION

Applying an interdisciplinary approach to the adoption of energy services is a unique research approach. This paper emphasizes that one of the main reasons for the considerable discrepancy between the potential for energy services in industry and their adoption is the existence of various socio-technical regimes in organisations. Moreover, the paper shows that the ESCO-market would benefit from leaving traditional regimes and moving into non-traditional ones. A number of promising means for reaching a satisfactory level of energy services in industry is outlined in this paper. If these findings were to be successfully adopted, this may lead to greater energy efficiency in industry, strengthen the ESCO businesses, contribute to lower production costs and increase the industries’ competitiveness. The paper is unique in the sense that it explores the topic of industrial energy efficiency and energy services using an interdisciplinary approach. By doing so, it carries the issue further than solely conducting research based on one theoretical framework, see for example [33], and actually contributes to new knowledge, which has not been possible to achieve using a non-interdisciplinary approach. The potential for energy services in terms of increased energy efficiency may be stated to be very large, based on a pessimistic assumption in the range of 600 GWh per year on a Swedish national scale.

From earlier research, knowledge exists of *which* barriers that exists, but the understanding of *how and why* barriers appear in a company needs to be deepened. By including an empirical analysis of socio-technical regimes and their negotiations and power relations, future research can contribute to the understanding of the existence of barriers and how they can be resolved. This calls for future empirical studies on the subject involving both ESCOs and manufacturing industry.

In conclusion, and even though much remains to be done as far as research and business model development are concerned, this paper has contributed to reduce the scarcity of research in the field of energy services in industry. Future research is suggested in the area, not least empirical research. The future will show whether energy services in industry, using insights from the interdisciplinary perspectives addressed in this paper, are not just a potential approach but as stated in this paper a key to the closure – or at least a major reduction of – the energy efficiency gap in industry.

6 REFERENCES

[1] D. Gielen, M. Taylor, 2007, Modelling industrial energy use: The IEA Energy Technology Perspectives, Energy Economics, 29: 889-912.

[2] EC, Directive 2006/32/EC of the European Parliament and of the Council of 5 April 2006 on energy end-use efficiency and energy services and repealing. Brussels: Council Directive 93/76/EEC, 2006.

[3] R. Roy, E. Shehab, eds. Proceedings of the 1st CIRP IPS2 Conference 2009. 2009, Cranfield University.

[4] M. Lindahl, G. Ö. Sandström, E. Sundin, A. Ö. Rönnbäck, J. Östlin, 2008, Learning networks: a method for Integrated Product and Service Engineering – experience from the IPSE project, In: Manufacturing Systems and Technologies for the New Frontier - Proceedings for The 41st CIRP Conference on Manufacturing Systems, Mitsuishi, Ueda, and Kimura, Editors. Springer: Tokyo. 495-500.

[5] P. Thollander, P. Solding, M. Söderström, Energy Management in Industrial SMEs, in Proceedings of the 5th European conference on economics and management of energy in industry (ECEMEI-5). 2009: Portugal.

[6] P. Rohdin, P. Thollander, 2006, Barriers to and driving forces for energy efficiency in the non-energy-intensive manufacturing industry in Sweden, Energy, 31: 1836-1844.

[7] P. Thollander, Towards increased energy efficiency in Swedish industry – barriers, driving forces and policies. 2008, Ph. D. thesis, Linköping University: Linköping.

[8] P. Bertoldi, B. Boze-Kiss, S. Rezessy, Latest Development of Energy Service Companies across Europe – A European ESCO Update. Ispra: JRC, European Comission, 2007.

[9] L. Trygg, Swedish industrial and energy supply measures in a European Perspective. 2006, Ph. D. thesis, Linköping University: Linköping.

[10] P. Thollander, P. Rohdin, M. Danestig, 2007, Energy policies for increased industrial energy efficiency: Evaluation of a local energy programme for manufacturing SMEs, Energy Policy, 35 5774-5783.

[11] SEEI (Swedish Energy Efficiency Inquiry), Vägen till ett energieffektivare Sverige (The road towards a more energy efficient Sweden). Stockholm: SOU (Statens offentliga utredningar), 2008.

[12] EEC (Energy Efficiency Committee), Vägen till ett energieffektivare Sverige (The road to a more energy efficient Sweden). Stockholm, 2008.

[13] P. Bertoldi, 1999, The use of long term agreements to improve energy efficiency in the industrial sector: overview of the European experiences and proposals for common framework. In the 1999 SAVE conference "For An Energy Efficient Millennium", Session III, 1-10.

[14] A. Forsberg, C. Lopes, E. Öfverholm, 2007, How to kick start a market for EPC Lessons learned from a mix of measures in Sweden. In ECEEE 2007 Summer Study - Saving Energy - Just Do It!, 211-218.

[15] M. Geissler, A. Waldmann, R. Goldman, 2006, Market Development for Energy Services in Europe. In ACEEE Summer Study.

[16] S. Sorrell, J. Schleich, S. Scott, E. O'Malley, F. Trace, E. Boede, K. Ostertag, P. Radgen, Reducing Barriers to Energy Efficiency in Public and Private Organizations. 2000, SPRU (Science and Technology Policy Research).

[17] P. Thollander, M. Ottosson, 2008, An energy-efficient Swedish pulp and paper industry – exploring barriers to and driving forces for cost-effective energy efficiency investments, Energy Efficiency, 1: 21-34.

[18] A. B. Jaffe, R. N. Stavins, 1994, The energy efficiency gap: what does it mean?, Energy Policy, 22: 60-71.

[19] P. Thollander, M. Söderström, P. Solding, 2009, Energy Management in Industrial SMEs. In 5th European conference on economics and management of energy in industry (ECEMEI-5). Portugal.

[20] J. Palm, 2009, Placing barriers to industrial energy efficiency in a social context: a discussion of lifestyle categorisation, Energy Efficiency, 2: 263-270.

[21] R. Kemp, D. Loorbach, 2006, Transition management: a reflexive governance approach, In: Reflexive Governance for Sustainable Development, Voss, Bauknecht, and Kemp, Editors. Edward Elgar. 104-130.

[22] R. R. Nelson, S. G. Winter, 1977, In search of useful theory of innovation, Research Policy, 6: 36–76.

[23] J. Ende, R. Kemp, 1999, Technological transformations in history: how the computer regime grew out of existing computing regimes, Research Policy, 28: 833-851.

[24] F. W. Geels, 2005, Technological Transitions and System Innovations: a co-evolutionary and socio-technial analysis. Edward Elgar, Camberley

[25] Thoresson Glad, Working Paper, in Tema Technology and social Change. 2009, Linköping university.

[26] M. Callon, 1991, Techno-economic networks and irreversibility, In: A Sociology of Monsters: Essays on Power, Technology and Domination, Sociological Review Monograph, Law, Editor. Routledge and Kegan Paul: London.

[27] W. Bijker, 1995, Sociohistorical Technology Studies, In: Handbook of Science and Technology Studies, al., Editor. Sage Publications: CA, USA.

[28] E. Shove, 1998, Gaps, barriers and conceptual chasms: theories of technology transfer and energy in buildings, Energy Policy, 26: 1105-1112.

[29] J. Palm, P. Thollander, 2009, Applying an interdisciplinary perspective on industrial energy efficiency. In the Scientific Conference on Energy and IT at Alvsjo fair, 97-110.

[30] A. Gebremedhin, J. Palm, Energianalys Borås. Eskilstuna: Swedish Energy Agency, 2005.

[31] C. Caffal, Energy management in industry. Analysis Series 17. Sittard, The Netherlands: Centre for the Analysis and Dissemination of Demonstrated Energy Technologies (CADDET), 1995.

[32] P. Rohdin, P. Thollander, P. Solding, 2007, Barriers to and drivers for energy efficiency in the Swedish foundry industry, Energy Policy, 35: 672-677.

[33] M. Bergmasth, M. Strid, Energitjänster på en avreglerad marknad - för en effektivare energianvändning? (Energy Services in a deregulated market – for a more efficient use of energy?), in School of Economics and Commercial Law. 2004, Gothenburg University: Gothenburg.