Energy efficiency in Swedish SMEs

Exploring barriers, knowledge creation and the role
of municipal energy efficiency programs

Fredrik Backman

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ABSTRACT

The overall aim of this thesis is to analyze how municipalities support small and medium-sized enterprises (SMEs) in their work to improve their energy efficiency. The purpose of this study is to increase the current understanding of how the methods and tools used by municipalities to assist SMEs in improving their energy efficiency influence the end results in terms of achieved energy efficiency, and how knowledge related to energy efficiency is created within SMEs. This thesis consists of two separate case studies that examine how two municipalities used a network approach to support SMEs in implementing energy efficient measures.

The theoretical frameworks of policy networks, barriers, communities of practice (COPs), and energy efficiency networks were used in this thesis. The findings are presented in the appended four articles. An overall conclusion is that networks that provide information in the form of a report with technological solutions as the only output are less likely to reach the agreed-upon goals. To achieve a more successful result, SMEs must be active in the process; they must be allowed to create knowledge and understanding that they perceive as valuable and relevant for themselves. Another important result is that information is not automatically transformed by SMEs into knowledge. In fact, SMEs need a platform from which they can negotiate the received information and use it to create knowledge through practice and social interaction. Finally, it was found that the type of technological solution is not insignificant; the type of energy efficient measure to be implemented and its level of complexity affect how a municipality should support energy efficiency work among SMEs.

Keywords: Policy programs, energy efficiency networks, communities of practice (COPs), barriers, knowledge creation.

Svensk sammanfattning

Svensk titel: Energieffektivitet i svenska små och medelstora företag – En undersökning av hinder, skapande av kunskap och kommunernas energieffektivitetsprogram

För att policyprogram och riktlinjer ska kunna utformas så att de leder till uppfyllandet av miljömål behöver kommuner samverkar med bland annat det lokala näringslivet. En form av samverkan som har börjat användas av kommuner är nätverk där man för samman företag med olika experter som tillsammans med kommunala representanter arbetar med att införa energieffektiva lösningar i dessa företag.

Syftet med denna avhandling är att studera hur kommuner har stöttat små -och medelstora företag (SMF) i deras arbete med att införa energieffektiva lösningar i sina verksamheter. Detta undersöks med hjälp av fallstudier av hur två olika kommuner har arbetat med att ge stöd till lokala SMF. Dessa två fall beskriver två olika sätt som kommunerna har jobbat med detta. Fokus i avhandlingen har varit inte bara på hur kommunerna har valt att stödja SMF utan också på hur SMF skapar kunskap och tar till sig information. Dessutom undersöks vilka faktorer i form av så kallade barriärer som kan tänkas hindra SMF från att införa energieffektiva lösningar i sina verksamheter.

För analys av den insamlade empirin så har olika teorier använts såsom policynätverk, barriärer, Community of Practice (COP) och energieffektiviseringsnätverk. Resultaten beskrivs mer utförligt i de bifogade artiklarna. Resultaten pekar på att nätverk där bara information i form av en rapport delges SMF så är sannolikheten låg att målen kommer att uppfyllas. Detta beror på att SMF inte automatiskt omvandlar delgiven information till användbar kunskap. Istället behöver kommuner skapa en plattform där SMF får möjligheter att arbeta med den delgivna informationen på ett aktivt sätt i ett relevant sammanhang som de anser att de har nytta av. På så sätt kan värdefull kunskap genereras via praktiker och sociala sammanhang. Ett annat viktigt resultat är att typ av teknisk lösning och komplexitetsnivå inte är oviktiga utan dessa måste kommunerna ta hänsyn till när de skapar olika policyprogram som stöd till SMF för att kunna uppnå energieffektiviseringsmål.

Nyckelord: Policyprogram, energieffektiviseringsnätverk, Community of Practice, barriärer, skapande av kunskap

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Fredrik Backman
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Introduction

Since the adoption of the UN's 2030 Agenda for Sustainable Development in September 2015, governments around the world have been working to transform their commitments into action (globalamalen, 2017). According to the agenda, present needs are to be met without affecting future needs in a negative way. This is to be done by aligning economic, social, and environmental elements. Implementation of the agenda will rely on countries' own sustainable development policies and programs. One of these commitments concerns climate change, and how states contribute to it (UN, 2016). Rising greenhouse gas (GHG) levels are increasingly viewed as one of the greatest threats facing the environment today (IPCC, 2014; Rockström et al., 2017). Therefore, discussions on climate change and how to reduce our impact on the climate occur at all levels, from global to local policy arenas.

The challenges of decreasing both our negative impacts on the climate and our consumption of natural resources are global concerns that have resulted in an increased interest in new and innovative technologies and political initiatives aimed at reducing GHG emissions. Although these problems are acknowledged as common concerns and initiatives have been taken, global progress on climate change is still too far behind to reach the established goal of limiting global temperature increase to 2 °C of preindustrial levels (EU, 2007). In other words, we have not yet established the world on a sustainable pathway toward a decarbonized energy system. As countries around the world work to shift toward clean energy, improving our energy efficiency—that is, using less energy to achieve the same ends—can speed up the transition to clean energy and increase its benefits across all sectors of the economy (IEA, 2016). If the EU and global climate change objectives are to be met, it is imperative that we change the way we use our energy (EC, 2017a).

One problem with mitigating climate change is that environmental aspects are highly dependent on economic factors, such as investment costs. Therefore, the European Commission is working to find new ways to make the economy of the EU more environmentally friendly and energy efficient, while doing so in a cost-efficient way. The commission's low-carbon economy roadmap, which builds on the 2020 climate and energy package, suggests the following (EC, 2017b):

- By 2050, the EU should cut GHG emissions to 80% below 1990 levels through domestic reductions alone.
- Milestones to achieve this reduction are: 40% emission cuts by 2030, and 60% by 2040.
- By 2030, there should be at least a 27% improvement in energy efficiency, with the ambition to reach 30% at the EU level.

In order to fulfill these EU goals, all sectors must contribute according to their technological and economic potential. According to the EU, European industries are capable of cutting their emissions by more than 80% by 2050. Doing so will require innovation as well as new ways of working with energy efficiency and investments.

The aim of this thesis is to increase current knowledge of how municipalities can contribute to and support improvements in the energy efficiency of processes in local industry. Swedish industry¹ accounts for around 38% of Sweden's total energy use; thus, it is a key actor group in determining whether or not the political agenda will be met. This situation creates both possibilities and problems regarding actions related to energy efficiency. Although many industrial actors want to invest more into energy efficient technologies, they also need to operate their business in an economically sound way and make investments that benefit their business. Diverging aims are a likely result; on the one hand, municipal initiatives are aimed at increasing energy efficiency according to a political vision, while on the other hand, industry holds different economic priorities (Stigson, 2009). This has contributed to the existence of a gap between potential energy efficiency and implemented energy efficient measures (Sorrell et al., 2004; Jaffe and Stavins, 1994; Thollander and Ottosson, 2010). This energy efficiency gap is theorized to depend on the existence of barriers such as lack of time, lack of funding, split incentives, and imperfect information, which hinder the implementation of energy efficient measures (Sorrell et al., 2004; Hirst and Brown, 1990; Weber, 1997). Barriers such as these can affect policy and policy programs, making it necessary to help local industry to overcome these barriers.

Global agreements to reduce GHG emissions through national regulations and incentives in order to stimulate related activities can both encourage and/or require local action.

¹ Industry is here defined according to the NACE Rev.2 (Eurostat, 2008; Equivalent Swedish: standard SNI10-33).

An overall trend is that many goals concerning the local level are set at the EU level. Therefore, EU directives have direct bearing on municipalities and on how they work with energy-related issues (SKL, 2017). Climate change is affected by both global and local levels in the sense that the causes and effects of climate change have both a global and a local dimension (Jänicke, 2017; Kern and Bulkeley, 2009). GHG emissions are created on the local scale in, for example, agriculture, forestry, cities, and towns, whereas many of the important driving forces for reduced emissions, such as policy initiatives or strategies, are decided and implemented on a global scale. As a result, municipalities can implement national or international climate objectives, and can also work proactively to establish independent local policy initiatives (Aall et al., 2007; Bulkeley, 2010; Castán Broto, 2017).

Municipalities are seen as key actors in improving energy efficiency and environmental sustainability; they have made it possible to lower a large portion of Sweden's emissions (SKL, 2017). There is often a strong political will to reduce emissions on the local level, and municipalities are directly involved with energy planning, energy advisory activities, and proactive work with climate change; in addition, municipalities often own local energy companies. Thus, the role of municipalities in increasing energy efficiency is an important one (Aall et al., 2007; Betsill and Bulkeley, 2007; Palm, 2006; SKL, 2017). Previous research has shown that it is necessary to formulate energy plans and strategies (Albrechts, L., 2004; Ivner, 2009; Fenton et al., 2015; Gustafsson et al., 2015); however, in order to generate local action initiatives, local authorities must adopt new working strategies when developing and implementing energy strategies and plans (Gustafsson et al., 2015). This insight will create a need for local policy makers to include new approaches to energy planning in the form of policies to help guide the future of a local energy system, and to develop methods in which traditional forms of authority are used together with collaborative partnerships with other actors (Bulkeley and Kern, 2006; Hamilton and Wills-Toker, 2006; Palm and Thoreson, 2014; Cloutier et al., 2015). This new focus implies a different way of working in which municipalities engage in dialogue with local industry and other actors in order to bring together different and sometimes diverging aims and assist local industry throughout the process of increasing its energy efficiency.

Municipalities have a vital role in improving energy efficiency, as can be seen in the emphasis the Swedish Energy Agency (SEA) puts on projects that directly involve municipalities.

To promote strategic energy work at the local level, the SEA initiated a program called Sustainable Municipalities from 2003–2014. As a part of this program, participating municipalities were inspired to develop local energy and climate strategies together. According to the Sustainable Municipality Program, and in alignment with earlier research (Koewener et al., 2011; Jänicke, 2017), local climate and energy strategies should be developed by creating forums and processes where regional actors can meet, share experiences, and develop common strategies and goals. From this perspective, energy strategies should not be developed by local authorities on their own, with a single goal based on a political vision. Instead, strategies should be developed in a collaborative and participative process that includes many actors. Involving many actors provides opportunities to work on an issue in a broader context by bringing in more problem-related views. It also better aligns with the decisions that are taken with non-municipal preferences, thus contributing to a working environment that is permeated by cooperation and trust between the involved actors (Palm and Thoreson, 2014).

One of the results from the Sustainable Municipality Program was a new focus on energy efficiency networks, which was strongly influenced by a successful German/Swiss model for working with energy efficiency in industry, called LEEN (Koewener et al., 2011). This focus resulted in plans for a new energy efficiency network project; the project will run from 2016–2020 and will involve around 350–400 local small and medium-sized enterprises (SMEs) with an energy use of at least 1 GWh/year, from a wide variety of sectors in Sweden.

Since municipalities in Sweden have limited power over most parts of their local energy system, actor participation is important for a successful outcome when preparing and implementing energy strategies. Therefore, the municipality must cooperate with other actors for a strategy to be implemented. If other actors are involved in the whole process of developing and implementing an energy strategy, they will become part of the process of sharing and developing knowledge, which in turn encourages action (Palm and Thoreson, 2014). This type of networking process may increase the capacity of different actors to meaningfully participate in the implementation process; it may also increase their willingness to take part in sustainable energy practices in the long run (Cuthill and Fien, 2005).

The purpose of this thesis is to gain further knowledge of how municipalities can contribute to and support the process of improving energy efficiency in local industry. The thesis examines this topic from the perspective of networks where different actors such as municipalities, enterprises, and experts work together to support the efforts of enterprises in implementing energy efficient measures. The concept of networks will be elaborated on through different theoretical approaches. I argue that working in a network structure with a focus on processes is insufficient to realize significant energy efficient measures in the participating SMEs. It is also necessary to look more closely at what happens in sociotechnical networks, where people struggle with technology, resources, and different aims. This thesis will help to broaden current understanding of how municipalities can support local companies in such processes.

I have been inspired by four theories, and have used parts of them in this work. The concepts I use come from policy networks, communities of practice (COPs), industrial energy efficiency networks (IEEN), and barrier theory. I use these theories in the accompanying articles in order to answer the specific questions that are raised in each article. In the final conclusion, I combine these theories to create a sociotechnical model on supporting energy efficiency work in industrial policy networks.

Aim and research questions

The aim of this thesis is to analyse how municipalities have supported SMEs in their work to improve their energy efficiency. The purpose of this study is to increase the current understanding of how the methods and tools used by the municipalities can influence the end results of attempts to improve energy efficiency, and how knowledge is created within SMEs. In order to fulfill this aim, three research questions (RQ) were formulated:

RQ 1: How did the two studied municipalities support SMEs in their energy efficiency efforts?

RQ 2: How do SMEs view barriers to energy efficiency, and what kind of municipal support is important to improve energy efficiency in SMEs?

RQ 3: Do different municipal policy programs exhibit different end results in terms of energy efficiency improvement in SMEs, and if so, how?

Layout

This thesis was written as a compilation thesis that includes an introductory chapter and four articles. The introductory chapter has the following layout:

- Introduction
- Energy use in Sweden
- Previous research
- Theoretical frameworks
- Method
- Summary of articles
- Discussion
- Conclusions

This chapter acts as a starting point by providing the background information that is necessary to understand the research area and the appended papers. It introduces the empirical area, previous research, theoretical framework, and methodology. The sections of this chapter provide a more general overview, while the articles examine the theoretical concepts, previous research, and so forth, in greater depth. Short summaries of the articles are also provided, and are followed by a discussion and a conclusion. This thesis should be viewed as a whole; therefore, it is recommended that the four articles be read before reading the conclusions.

Energy use in Sweden

Sweden has formulated climate and energy goals for 2020, and is committed to reducing GHG emissions by 17% by 2020, compared with 2005 levels. Sweden's national climate goal is for our GHG emissions to be 40% lower in 2020 than they were in 1990. Another goal is to increase the share of renewable energy to 50% of the total energy use in Sweden by 2020. The Swedish government has also decided on a target for increasing energy efficiency (which it phrases as "reduced energy intensity"): to reduce energy intensity by 20% by 2020, compared with 2008 levels (Regeringen, 2017b).

In 2016, a cross-party committee on environmental objectives, in which seven of the eight political parties in parliament participated, agreed on an energy policy for the future. This agreement aims at providing long-term thinking and creating predictability for energy-use actors and for society as a whole. One of the goals of this agreement is for Sweden to achieve 50% more efficient energy use by 2030, compared with 2005 levels. This energy efficiency goal aligns with the EU's ambition to significantly reduce energy use by 2030. The idea behind this policy goal is that successful work on energy efficiency strengthens Sweden's competitiveness, reduces our environmental impact, and creates many other benefits for society (Regeringen, 2016).

Providing long-term thinking and creating predictability is important for the involved actors because changes to the energy system generally involve major investments in electricity and district heating networks, transport infrastructure, and industrial processes, which have long lead times (SEA, 2015c).

The Swedish energy system is partly based on domestic renewable energy sources such as water, wind, and biofuel. Regarding transport, a large part of the energy supply comes from imports of biofuels, and fossil fuels such as oil and natural gas. Swedish electricity production is largely based on hydropower and nuclear power; however, increased expansion of wind power and the use of biofuels contribute to the production of electricity and heat (SEA, 2017).

Sweden's total energy use can be divided into three user sectors: the industrial sector, the transport sector, and the residential-and-services sector. In the industrial sector, biofuels and electricity are primarily used to power processes.

Energy use in the transport sector mostly consists of petroleum, diesel, and aviation fuel, although it includes electricity and an increasing proportion of biofuels. The residential-and-services sector mainly uses district heating, electricity, oil, and biofuels as energy sources (SEA, 2017).

In 2015, the total energy use in the three user sectors was approximately 370 TWh (a loss of 171 TWh in the energy system was not included). The industrial sector and residential-and-services sector accounted for 140 TWh and 143 TWh, respectively, while energy consumption by domestic transport amounted to 87 TWh, as shown in Figure 1 (SEA, 2017).

Figure 1 Total final energy use per sector, 2015 (Source: SEA, 2017)

Electricity is the most common type of energy carrier in Sweden. In 2015, the total electricity consumption was 122 TWh. The residential-and-services sector uses the most electricity, followed by the industrial sector. Oil products are the second-largest energy carrier after electricity, and their final use amounted to 91 TWh in 2015. In Sweden, petroleum products are almost exclusively used by the transportation sector. Biofuel is the third-largest energy carrier, and its final use in 2015 was 84 TWh (Figure 2). Electricity is primarily used to drive different types of mechanical manufacturing processes. In non-intensive industrial companies and industrial SMEs, most energy is used in supporting processes (Thollander and Palm, 2013).

The high electricity consumption of industry and the residential-and-services sector is largely due to Sweden having a cold climate and a comparatively large proportion of electricity-intensive industry (SEA, 2017). Another reason is that the cost of fossil fuels has increased, leading the industry and residential-and-services sectors to replace oil with electricity. In addition, increased automation and use of information technology (IT) have increased the dependency of the services sector, industrial sector, and ordinary household consumers on electricity (Ekonomifakta, 2018). In the transport sector, energy use has generally decreased from 2007–2015 because of improved energy efficiency, often due to a transition to more fuel-efficient vehicles (SEA, 2017). Other factors that affect Sweden's energy use are taxes, the rise of energy prices, increased energy efficiency, investments, technological development, and changes in industry's product mix.

Figure 2 Total energy use per energy carrier, 2015 (Source: SEA, 2017)

Energy use in the industrial sector

Biofuels and electricity are the dominant energy carriers in Swedish industry, and the industry's use of electricity accounts for more than one third of Sweden's total energy use (Figure 3). In 2015, biofuels accounted for 40% and electricity for 35% of industry's final energy use. The type of fuel that is used varies in different branches of industry; however, for SMEs, electricity is the main source of energy (Energimyndigheten, 2017). The decline in electricity consumption in recent years is due, among other things, to the fact that the electricity-intensive production of mechanical pulp has fallen. The reduced power consumption is also due to the fact that production processes have become more energy efficient overall.

In Sweden, a few industries account for most of the energy use of the industrial sector. These industries—the pulp-and-paper industry, the iron-and-steel industry, and the chemical industry—used three quarters of the final energy use of the industrial sector in 2015 (SEA, 2015c). The pulp-and-paper industry is the industry that uses the most electricity in Sweden. Therefore, changes in this industry have a significant impact on the industrial sector's total electricity consumption. The engineering industry, although it is not counted as an energy-intensive industry, still accounts for 6% of the industrial sector's final energy use due to its large share of Sweden's industrial output. Other industries, such as the mining, food, textile, graphics, wood, and earth-and-stone industries, accounted for 18% in 2015 (SEA, 2015c).

Figure 3 Total energy use for the industrial sector, 2015 (Source: SEA, 2017)

Energy directive

The Swedish government is trying to encourage enterprises to increase their energy efficiency in a proactive way. One way of doing this is through the Energy Efficiency in Large Enterprises Act, which was introduced as part of Sweden's implementation of EU Energy Efficiency Directive 34, and which has had an impact on improving energy efficiency. According to this act, large companies must perform quality-assured energy audits at least every four years.

In general, an energy audit investigates the energy used by an enterprise's support and production processes. This investigation can take from a single day to months to accomplish. When performing an energy audit, several steps occur: (1) Meetings are held between the energy expert and the involved enterprise in order to discuss the extent of the audit. (2) Onsite visiting and data collection through metering is done. (3) Analysis and, if necessary, a follow-up is performed. (4) A meeting is held between the energy expert and the involved enterprise to discuss the current energy use and the proposed energy efficient measures. (5) The enterprise then receives a report that outlines the current energy use and the proposed energy efficient measures (Thollander and Palm, 2013).

The purpose of an energy audit is to highlight how much energy is used each year to operate the business, and to provide cost-effective suggestions on how this energy use can be reduced. SMEs are not included in the Energy Efficiency in Large Enterprises Act; therefore, SMEs are not required to carry out energy audits. Instead, SMEs are offered an incentive to improve the energy efficiency in their operations: They can apply for financial support, which will cover half the cost of an energy audit (no more than EUR 5000). In order to be eligible for this economic support, the SME must have an annual energy consumption of more than 300 MWh (SEA, 2015c). These actions on the part of the Swedish government have influenced how different policy programs are designed, as is discussed later in this thesis.

Previous research on energy efficiency, policy networks, and knowledge creation

This section provides a background on why I chose to direct my studies to certain topics and how this choice has influenced my view on energy efficiency in SMEs. I will discuss influential approaches that have guided my research and explain why I used them as a starting point for my analysis. This chapter also provides a background and introduction to the previous research that I have used in my articles, and expands on what is said in the articles. Therefore, this section acts as an overview and introduction to the concepts and theoretical perspectives used later on in the articles.

Previous research on energy efficiency has focused on a wide variety of research fields such as economics, engineering, science and technology studies (STS), strategic management, behavioral economics, and industrial organization. Studies in these areas have dealt with questions similar to the questions that are central to this thesis. I draw on several theoretical frameworks and explore energy efficiency from different perspectives. The reason for this will be explained in Chapter 3, where I discuss what theories were used, why, and in what articles.

Despite the considerable amount of attention being paid to climate mitigation and energy efficiency in general, most of the research examining the work of different actors in improving energy efficiency has been techno-economical in nature (Sorrell et al., 2004; Thollander and Palm, 2015; Sovacool, 2014). Therefore, it is of interest to bring in a more sociotechnical perspective to this research field in order to complement the existing research on energy efficiency (Sovacool et al., 2015). This reasoning is expanded in articles 3 and 4.

In this thesis, the term sociotechnical means that both technical and human factors should be considered, and that these factors are inseparable from each other. Thus, when studying energy efficiency, social and human factors are as important as technological factors and have a direct influence on the choice of technological solutions. For example, a person's skill, contextual setting, prior knowledge, specific theories, and practices can have a large impact on how energy efficiency is treated or handled in SMEs. I will specifically focus on knowledge creation, which is an active process with contextual and cultural underpinnings (Sismondo, 2010).

Here, information is not seen as something that is necessarily translated directly into useable knowledge and solutions. Instead, how information is interpreted and understood depends on the individual and on the social setting.

In the next sections, I will discuss the areas of research that have influenced my research and set the topics for my articles.

Previous research on the energy efficiency gap and barriers

On global, EU, and national levels, improved industrial energy efficiency is becoming increasingly important with regards to the environment, public health, and business. Improved energy efficiency is considered to be one of the most promising means to reduce the CO₂ emissions resulting from the use of fossil fuels (IPCC, 2014); it also has direct economic benefits such as increased competitiveness and higher productivity (Worrell, 2003). It is a common view that energy efficiency offers a “win-win” opportunity for both society and companies (Allcott and Greenstone, 2012; Johansson and Thollander, 2018). Despite this, research into energy efficiency for both energy-intensive and non-energy-intensive industries has found that energy efficiency is often not a high priority, and that much more could be done because great potential for improvement still exists (Thollander and Ottosson, 2010; Rohdin and Thollander, 2006; Thollander and Ottosson, 2010; Lu et al., 2013). I will follow Rohdin and Thollander’s (2006) definition of non-energy-intensive companies: that is, a non-energy-intensive company is one whose energy costs do not exceed 2% of its turnover.

Another delimitation in this study is that the focus of this thesis is on SMEs. More than 99% of the companies in the EU’s non-financial business economy can be considered as SMEs when the number of employees is used as a criterion. This means that around 22 million companies fall into this category (EC, 2016). I will use the same definition of SMEs as that used by the EU Commission: that is, an SME is an enterprise with fewer than 250 employees, an annual turnover not exceeding 50 million euro, and/or an annual balance sheet total not exceeding 43 million euro. Small companies are defined as companies with 10–49 employees, while medium-sized companies employ 50–249 people. In Europe, SMEs are estimated to be responsible for the consumption of approximately 13% of total energy demand (IEA, 2015).

Even though the overall energy use among SMEs is usually much lower than the energy use in larger and more energy-intensive companies, it is important to consider the large economic impact of SMEs on a country's economy; thus, SMEs are an important group to target for policy intervention or policy programs. This means that EU and national goals for improved energy end-use efficiency among industrial SMEs should not only be designed for the purpose of improved energy efficiency; they should also be designed for economic impact, as improved energy efficiency will support the long-term survival and international competitiveness of SMEs. In addition, targeting SMEs is a cost-effective energy end-use policy measure, since SMEs have often not exploited their low-cost potential, compared with large firms (Thollander et al., 2014).

Two of the most influential theories in energy efficiency research discuss the notion of an energy efficiency gap that exists due to barriers to energy efficiency. Hirst and Brown (1990) and Sorrell et al. (2004) are major influencers in this field. Therefore, I will discuss these two streams of research later on and argue for a more sociotechnical view. The existence of an energy efficiency gap and research on the barrier theory are deeply embedded in the discourse on energy efficiency and in policy directives on all levels, making it important to reflect upon both these perspectives. In this thesis, and especially in article 2, both perspectives provide a background and a theoretical viewpoint.

Energy efficiency gap

In the scientific literature and in EU policy documents on energy efficiency, cost-effectiveness is often used to argue for improved energy efficiency, thereby leading to reduced costs and enhanced competitiveness for companies (Hahn and Stavins, 1992; Sorrell et al., 2004). However, policy documents and research reveal that cost-effective energy measures are not always implemented, even though doing so would be a rational response by companies. This difference between the level of realized energy efficiency measures in practice and the level that is economically profitable is often described as the "energy efficiency gap" (Bertoldi, 2001). This is a prominent view in policy documents on EU, national, and municipal levels and in energy efficiency research (Blumstein et al., 1980; Hirst and Brown, 1990; Gruber and Brand, 1991; Stern, 1992; DeCanio, 1993; Sorrell et al., 2004; Brown, 2001; Rohdin and Thollander, 2006; Fleiter et al., 2011; Trianni and Cagno, 2012; Chai and Yeo, 2012).

Backlund et al. (2012) argue that the energy efficiency gap, which exists due to energy efficient technological misalignment, must be complemented with energy management. By combining investments in energy efficient technologies with continuous energy-management practices, increased energy efficiency can be reached. The word “practice” is important here. I will come back to this topic in article 3, where I argue for the importance of practice in regards to energy efficiency programs. Backlund et al. (2012) consider it important to work with energy-management components and technological solutions in future energy policies, if the EU’s energy-savings targets for 2020 and 2050 are to be met. Successful energy management often consists of three parts: energy auditing to gather data about energy use in companies, courses and training for employees to increase knowledge and day-to-day awareness in order to keep up the improvement work, and following routines to prevent unnecessary energy use (Abdelaziz et al., 2011). A higher level of energy efficiency can be reached when energy efficient technology and successful energy-management practices are combined and implemented (Johansson and Thollander, 2018). This perspective moves energy efficiency work away from being purely technological and toward a more sociotechnical view.

Thus far, academic literature and policy documents have focused mainly on improving energy efficiency through technical solutions and by examining potential opportunities for energy efficiency. Less research has been done to examine the role of energy-management practices for SMEs involved in policy programs (Backlund et al., 2012). In article 3, I more deeply examine the question of how SMEs actually work with energy efficiency in practice.

Barriers

In the municipal policy programs that were followed in this thesis, the focus was on lowering the energy efficiency gap by helping SMEs overcome different barriers. Therefore, this thesis focuses on barriers rather than on drivers to energy efficiency. The origins of the energy efficiency gap discussed above can be explained by a set of barriers that may be divided into different categories (Sorrell et al., 2004; Reddy, 2013). One model that is widely used to explain the difference between an optimal level of energy efficiency and the current level is the barrier model (Sorrell, 2004). In this model, different barriers to energy efficiency hinder the adoption of cost-effective energy efficient measures (Sorrell, 2004; Thollander and Palm, 2015).

According to Sorrell et al. (2004), barriers to energy efficiency can be defined as postulated mechanisms that inhibit a decision or behavior that appears to be both energy efficient and financially sound. Lack of time, lack of funding, technical and financial risk, hidden costs, split incentives, and bounded rationality are examples of these kinds of barriers. In the energy efficiency discourse, barriers are categorized in different ways in addition to Sorrell's (2004) method. For example, both Weber (1997) and Chai and Yeo (2012) use their own categories. Throughout this thesis, and especially in article 2, I follow Sorrell's way of categorizing barriers. Barriers are heterogeneous in nature and differ between SMEs due to organizational, social, and technical factors, thus implying a contextual situation. For SMEs, some barriers to energy efficiency are more difficult to overcome than others. In a recent report by the IEA (2015), the most prominent barriers among SMEs are listed as follows:

- **Limited information on energy efficiency improvement opportunities:** SME managers often lack the time and motivation to obtain, process, and act on energy efficient opportunities.
- **Limited in-house skills and expertise to identify and implement projects:** SMEs often focus their resources on daily business and have little time to develop expertise beyond day-to-day operations.
- **Difficulty accessing capital to finance energy efficiency improvements:** Even though energy efficiency opportunities exist and can be realized by measures with little or no cost, SMEs need capital to implement more far-reaching efficiency improvements.

Since barriers are heterogeneous and vary between SMEs in all the industrial sectors, it is important to analyze and identify existing barriers to energy efficiency before running energy efficiency programs (Trianni and Cagno, 2012). The IEA (2015) states that there are three areas—information, capacity building, and financing—that must be considered when designing a program that overcomes the abovementioned barriers and increases realized energy efficiency measures for SMEs:

- **Information measures:** These include energy audits, technology demonstration projects, site visits, case studies, “how to” guidance materials, fact sheets, lists of typical energy efficiency projects, list of energy efficient equipment, and workshops.
- **Capacity building measures:** These measures develop the energy efficiency skills and knowledge of in-house personnel, and include energy audits, training, personal experience sharing, and seminars.
- **Financing measures:** These measures assist SMEs by providing access to capital and other financial resources such as free or reduced-price energy audits, external consultations, and investment plans.

In my third and fourth articles, I analyze the question of what is important in an energy efficiency program for SMEs. In these articles, I not only look at previous research regarding energy efficiency programs, but also compare my two case studies in order to draw conclusions on how, for example, municipalities can structure their policy programs and work with local companies.

Policy networks

Since barriers are heterogeneous and vary in relevance for SMEs, the design and implementation of energy efficiency policies cannot be the same for all companies (May et al., 2017; Stern et al., 1986). Policy makers often have a singular objective for their environmental regulation or policy vision, such as protecting the quality of the environment or the health of the local population in a top-down fashion. The problem with this perspective is that sustainability depends not only on environmental issues but also on social and economic issues. A mutual dependency exists between these issues that requires policymakers to face a more complex situation involving tradeoffs and constraints among multiple actors (Hahn and Stavins, 1992). For example, conflicts may occur between ambitious energy efficient goals and the actual possibilities for SMEs to implement the required measures. Such conflict often leads to a gap between what is theoretically possible and what SMEs actually do, or are willing to do, in reality.

Policy interventions to improve energy efficiency are usually done in order to lower barriers that prevent the realization of cost-effective investments in energy efficiency (Brown 2004).

If policies to encourage investments in improved energy efficiency are to be successful, it is essential to understand not only the nature of these barriers but also the context that SMEs operate in (Reddy, 2013). It is not uncommon for municipalities to work with establishing energy efficiency policies. For example, many Swedish municipalities have worked with the Swedish Energy Agency (SEA) in different projects, such as Sustainable Municipality, where the focus is on increasing the implementation of energy efficient measures in local SMEs in order to make local communities more sustainable (SEA, 2015a).

Municipalities can take a motivating or developing role in these types of project, but they cannot act on their own. Instead, they need to cooperate and integrate their plans and strategies with the involved SMEs. Municipalities need to act as meta-governors; that is, they need to relate and coordinate their activities to self-governing networks (Jessop, 2003; Sørensen and Torfing, 2007). In my first article, I discuss these networks in terms of policy networks. Previous research has shown that municipalities often assume a great deal of responsibility and do more than is required of them from national and EU directives. As a result, public authorities may implement a set of policy programs to overcome this efficiency gap (Bulkeley and Betsill, 2013).

Municipalities can work proactively to help local companies overcome energy efficiency barriers through their policies. This is often done in the form of industrial energy programs (Paramonova and Thollander, 2016). These policy programs may contain different types of actions to encourage SMEs to increase their realized energy efficient measures. For example, a subsidized energy audit program can stand alone or be part of a broader program that includes both an economic part in the form of a subsidy and an information part made up of an energy audit report and an investment plan that are delivered to the company (Thollander et al., 2015; Price and Lu, 2011). Through these programs, the adoption of energy efficiency measures is expected to be accelerated, as better information is provided about technology options and related energy cost savings. Since research has found that information-related barriers seem to be prevalent in smaller organizations, providing information through energy audits has become a one-sided rationale for many government programs that focus on SMEs (Schleich and Fleiter, 2017).

However, it is clear that facilitating cooperation between public authorities and local companies improves the effectiveness and efficiency of climate and energy policies. This means that with input from local SMES, the establishment of ambitious municipal energy efficiency targets can be transformed into realistic and achievable goals (Bertoldi, 2001; Stigson et al., 2009). Therefore, municipalities designing policy programs should look beyond potential cost-effectiveness—in which a reduction of X MWh/year is translated into a monetary value—as a policy goal. It is also necessary to understand the actual needs of SMEs and to tailor programs to meet these needs, since SMEs' perception of different barriers can vary (Trianni and Cagno, 2012). By supporting local SMEs in this manner, energy end-use efficiency policies have an important role in removing barriers to energy efficiency (Thollander et al., 2015).

In article 1, I analyze the work of a municipality that tried to implement a policy program that was designed in-house based on the municipality's environmental vision document. The results from this analysis raised many questions about how such a program could be designed and implemented differently, and led me to investigate further by examining how another municipality worked with its policy program (article 3). The research conducted for article 1 also made it possible for me to experience firsthand the tensions that can exist in these types of programs when a political vision comes up against the reality of how SMEs operate. This research later led to articles 2, 3, and 4.

Previous research on knowledge creation

Social science research argues that a change is needed in how energy efficiency research is performed, and claims that earlier policy initiatives are lacking in the social contexts of energy saving action and in how such action is intertwined with the technical (Shove, 1998; Lave and Wenger, 1991). Technical change should not be viewed as a linear unidirectional process of technology transfer from actor to actor. People do not absorb abstract knowledge and then implement optimal energy efficient measures (Shove, 1998; Sorrell et al., 2004). Rather, decisions regarding industrial energy efficiency are shaped by social processes and built on the knowledge, routines, institutions, and methods established in networks (Guy and Shove, 2000; Callon, 1991; Bijker, 1994).

Within this shift in perspective lies a change in how knowledge is perceived: Knowledge is not considered to be composed of undeniable facts or objective truths; rather, knowledge is enacted and depends on context, and may therefore vary between actors (Berger and Luckman, 1967; Latour, 1987).

Energy efficiency networks

Research has shown that combining a comprehensive energy audit with a management scheme appears to improve companies' internal work with energy efficiency; this is particularly true for the non-energy-intensive sector and for SMEs (Koewener, 2011; Jochem and Gruber, 2007; Backman, 2018). In this way, several measures can be used and combined to build internal expertise within a company, including written materials, workshops, education courses and training, onsite training, and capacity building through active participation in events such as energy audits. Therefore, an energy efficiency training course in which actors come together should involve the opportunity for the actors to meet in order to share their experiences and learn from each other specific skills or knowledge. Some type of capacity building should be an integral part of an energy efficiency program for SMEs. For example, SMEs are unlikely to be able to send representatives to attend a lengthy training course, since two of the barriers that are experienced by SMEs relate to a lack of time and money. Therefore, short focused training sessions with a single theme are more likely to be effective (IEA, 2015). Larger organizations are better able to follow up on energy audit recommendations because they often have better in-house knowledge in the form of a designated energy manager, along with the financial resources needed to implement an audit's investment recommendations. SMEs do not usually possess these advantages (Schleich and Fleiter, 2017).

It is not only new technology that is relevant when working with energy efficiency measures. There is still potential to update older production processes with decreased efficiency by making use of and comparing with the existing best practice (Bertoldi, 2001). Often, SMEs are unaware of their energy use and of their potential for energy efficiency. Even though solutions to improve energy efficiency in the form of best practice technology can be simple, such as installing new LED lighting or changing leaking compressors, it can be a complex task for an SME to implement such projects (Saygin et al, 2011).

This is because the people who are responsible for energy efficiency in SMEs usually deal with this subject in addition to their regular job, leading to split incentives. Financial subsidies, energy audits, and investment plans are a good beginning; however, since SMEs often lack the skills necessary for dealing with energy efficiency, something more is needed. Left to their own devices, SMEs will lack the right tools. This can be seen in later research, which has shown that SMEs must participate with energy efficiency learning on a deeper level than just receiving an energy audit report or attending some general seminar (Backman, 2018; Palm and Backman, 2017).

There is a long-standing tradition when it comes to energy efficiency practice of focusing on the result from an energy audit that provides a technical solution. This tradition leads SMEs to work on the implementation of energy efficient technology in a narrow fashion, while neglecting the importance of the human aspect. That is, educating employees and making them aware of their energy use and its effects on processes in the company could change their behavior and lead to reduced energy use (Johansson and Thollander, 2018).

The concepts discussed by Johansson and Thollander (2018) were researched earlier and implemented in Germany and other countries; most recently, these concepts have been implemented in Sweden, where SEA has instigated a project involving 350–400 SMEs to work actively with energy efficiency in different networks (SEA, 2015b). In the German study on energy policy programs, it was shown that when medium-sized companies in Switzerland and Germany worked within learning energy efficiency networks, there was a doubling of realized measures, compared with other programs with stand-alone energy audits (Koewener et al., 2011). Inkpen and Tsang (2005) argued that networks provide SMEs with access to knowledge, resources, and technologies. This is because research shows that knowledge transfer is enhanced by intensive social interactions between actors. The social dimension improves the ability of actors to acquire new knowledge from networks, and facilitates the transfer of knowledge between network members. This perspective aligns with Bulkeley and Betsill's (2005) idea that local governments should act via networks in which business and the local community are involved. This can be a way for local governments to combine their environmental vision with the economic boundaries of SMEs, and go beyond the limits of their authority in addressing climate change issues (Bulkeley and Betsill, 2005).

When different actors bring contradicting or incompatible goals into projects, inter-partner conflict can arise. Conflict among actors in a network collaboration often results in frustration and dissatisfaction with the program. Such a negative and untrustworthy climate is not beneficial to the flow of knowledge between the actors in the network. When studying intra- and inter-departmental conflict within companies, Schnake and Cochran (1985) found that when the actors have a low level of understanding of a goal, conflict and decreased work motivation often ensue. In other words, if different actors can abide by and understand a goal, inter-partner conflict is reduced. A trusting environment often furthers the negotiation and establishment of common goals. When the goals and the steps by which the actors are to accomplish them are clearly stated in a network, a common understanding and the means to achieve the collaborative purpose are established among the actors, leading to a more positive atmosphere (Das and Teng, 1998).

In articles 3 and 4, I argue against the simplified generalization that abstract knowledge from energy audits coupled with an investment plan can be directly used by SMEs with varying degrees of knowledge of energy efficiency work. In fact, energy audits do not usually lead to the realization of the full energy efficiency potential of an SME. Rather, improved energy efficiency is related to knowledge creation and to how the information SMEs are given is made useable in a specific context, so that the SMEs can handle the knowledge and become proficient in energy efficiency work. Here, the change from a technical to a sociotechnical perspective is important. For municipalities that are formulating policy plans, in addition to giving financial aid, it is important to reflect on how SMEs can learn and incorporate new knowledge into their business, given their lack of time and skills in that field.

Creation of knowledge

Information is often stated in research to be one of the most common barriers to energy efficiency for SMEs. Information-related barriers involve either insufficient information or a lack of the time and costs required for information gathering (Thollander et al., 2007). Since SMEs lack the resources or skills to search for information on their energy efficiency potential and the means to reach it, municipalities can have a role to play in information collection.

By helping SMEs collect information, municipalities can assist in eliminating informational barriers, and can thus improve realized measures (Paramononva and Thollander, 2016).

For this reason, public policy interventions are often in the form of energy audits, since this can serve as a means to overcome informational barriers (Schleich, 2004). The idea here is that if energy efficiency investments are not being made by SMEs due to a lack of information about available technologies or about ways to decrease their energy use, then it follows that by providing SMEs with specific information from experienced energy consultants, such informational barriers can be overcome. In this way, it is theoretically possible to influence companies' decisions regarding implementing energy efficient technologies or decreasing their energy use. However, social science research argues that this reasoning is flawed because actors do not always act rationally or optimize their processes in an economically optimum way (Winther and Wilhite, 2015; Guy and Shove, 2000; Latour, 1987).

Guy and Shove (2000) call for a change in how energy management is viewed. These scholars argue that technical change is a social process that affects actors in different ways, such that more or less energy efficient choices are made in response to changing opportunities and internal and external pressures. Information regarding technologies is not transferred unperturbed from external experts to SMEs in a linear fashion. Instead, actors adopt and adapt strategies and practices through knowledge creation that suits their contexts. Therefore, abstract energy audit reports and investment plans are transformed by SMEs into information that belongs to them and that is of possible value for their organization.

With this said, performing an energy audit is a vital first step in improving energy efficiency in SMEs (Caffal, 1995; Bunse et al., 2011). However, it is important to acknowledge that the audit by itself does not result in energy savings (Schleich, 2004; Backlund and Thollander, 2014). Rather, an energy audit should be seen as a helpful measure that allows SMEs to define areas for improvement and identify their potential for more energy efficient measures. The presence of an external energy consultant can partly replace the lack of energy managers in SMEs (Schleich, 2004). However, it is necessary to enable SMEs to work with energy efficiency in a way that allows them to transform information and external knowledge into something that fits their context and business.

I deal with this subject in article 4, where I compare the two case studies with each other against a background of previous research on policy programs in energy efficiency. There, I examine how knowledge is not a fact in this context; rather, it is something that is created between different actors and is therefore interpreted differently by different actors.

Previous research relating to this thesis

My point of departure in this thesis is that an energy efficiency gap exists between theoretical and realized cost-effective energy efficient measures. This gap is due to the existence of barriers that impede SMEs in their implementation of energy efficient measures. From this starting point, I broaden the discussion by bringing in a sociotechnical perspective; I argue that technological solutions must be complemented by an energy-management aspect, in accordance with research done by Backlund et al. (2012). It is also important not to view technological solutions and energy management as two distinct areas. Instead, the technical and social aspects must be viewed as being intertwined with each other and codependent. I further argue that SMEs cannot be left on their own after an energy audit, since they often lack the necessary knowhow and skills to interpret energy audits. Here, networks (later described using the communities of practice (COP) framework) are a way for municipalities to create a support process whereby SMEs can learn and work with energy efficiency. I emphasize that a practice component is important, since knowledge is contextual and is created in a social environment, rather than being translated in an unaffected way between different actors (Latour, 1987; Lave and Wenger, 1991). This emphasis also leads to a reflection on how information and knowledge is related.

Theoretical frameworks

This chapter discusses the theoretical concepts underlying the four articles and problematizes them on a deeper level than was possible in the individual papers.

One of the points made in the study by Simpson et al. (2004), which I use in the last two articles, is that the concept of energy efficiency improvements is a rather abstract idea for many SMEs. This abstraction leads to difficulties; it can—and in some cases does—affect the policy programs of municipalities that want to work with sustainability issues (articles 3 and 4). One of the effects seems to be that SMEs require more support and guidance than was previously thought. A lack of adequate support and guidance can have a negative impact on the adoption of more energy efficient measures (Simpson et al., 2004).

Bulkeley and Betsill (2005) also advocate the view that municipalities should provide support for sustainability work. These scholars argue that such support should be in the form of networks that involve both business and the local community. These networks would offer a way for municipalities to govern this process of implementing energy efficient measures while fulfilling their environmental visions (Bulkeley and Betsill, 2005; von Malmborg, 2007). The need for municipal-business networks is supported by research that indicates that a network approach will lower barriers for companies in their work with energy management (Paramanova and Thollander, 2016; O’Keeffe et al., 2016).

This finding led me to focus my research on local municipal energy networks, and to examine how municipalities try to work with local companies in order to improve their energy efficiency work. I view municipalities as important actors that can be proactive, but that also act as support for local SMEs in their work to improve their energy efficiency. In the text below, I outline the theories that are used in this thesis. Figure 4 illustrates how these theories are used in each article.

In this thesis, I use the theories of policy networks and of energy efficiency networks. I made this choice because the municipality in case study 1 was strongly involved in deciding how the network should be constructed and what actors should be involved; in addition, the network was run by the environmental strategist, and was therefore a policy network. In case study 2, however, the involved municipality only supported the networks financially, by paying for the external project leader; it did not influence how the network should be constructed, who should be in it, or how it should be run. Therefore, the network in case study 2 was more in line with the type of energy efficiency learning networks being used in Germany.

Figure 4 Theories used in this thesis and in the accompanying articles

Different types of networks

Firm networks

Huggins (1998a, b) suggests that network initiatives can be divided into two types: (1) informal network initiatives, and (2) formal network initiatives. In informal network initiatives, policies bring together firms to share information, solve common problems, or acquire new skills through voluntary contact and interaction.

Informal network initiatives have further been divided into informal general network initiatives, where the interaction primarily consists of information exchange, and informal task-specific initiatives, which involve a form of workshop-based learning aimed at achieving some common end result.

Inter-firm networks consist of companies that are connected with each other through some form of sustained interaction, within which there is necessarily some type of common goal (Huggins 2001). Rosenfeld (1996) extends this split-up of networks by saying that networks may take the form of formal “hard” networks that involve firms joining together to co-produce, co-market, co-purchase, or cooperate in product or market development, or more informal “soft” networks that involve firms joining together to solve common problems, share information, or acquire new skills. In many cases, inter-firm networks have been offered as a way to achieve economic success, if they are used in a correct context (Staber, 1996).

A common view of sustainable development is that it requires technical, organizational, and institutional change and innovation to become reality (Hartman et al., 1999). Inter-organizational collaboration in networks carries the possibility of promoting the potential for learning that is needed for environmental transformation and sustainable development. This process can take the form of learning-action networks that cross over business organizations and different stakeholders in society (Clarke and Roome, 1999).

Research has found that informal network initiatives, especially those that are task-specific within a wider business-support strategy, generate the greatest benefits for companies in terms of learning and innovation capabilities. It can then be claimed that increasing the time companies commit to initiatives positively affects their sense of belonging within the network, as trust between companies is created. Projects based on informal task-specific initiatives appear to offer the most effective means of inter-company contact (Huggins, 2001).

In article 3, I use the notion of a softer informal task-specific network, since the idea behind that municipality’s policy program was to bring firms together to share information, solve common problems, or acquire new skills through voluntary contact and interaction with a practice dimension. The important factors that I focus on in articles 3 and 4 are: common problems, sharing of information, acquiring new skills, and the importance of context and practice.

Policy networks

Since municipalities operate at the local level, it is ideal for them to act as a bridge between national policy and local actors by developing tailored solutions and establishing links between all the different policy areas (Clar and Steurer, 2012; Corfee-Morlot et al., 2009). Here, *policy* should be seen as a set of ideas or plans that is used as a basis for making decisions and that is often used in politics. One way of acting as a bridge is to work in networks that emphasize the local economy, recruit suitable SMEs, and involve existing local business networks (Rowe and Enticott, 1998).

Kickert et al. (1997) define policy networks as “stable patterns of social relations between interdependent actors, which take shape around policy problems and/or policy programs.” Article 1 analyzes the municipality’s activities to support energy efficiency in industry by examining the activities among the actors gathered in a policy network.

Energy gaps and barriers

According to research, companies can profit greatly from working with energy efficiency in a structured way. For example, research shows that SMEs can lower costs, gain competitive advantage, and simultaneously create a sustainable business by adhering to environmental good practices (Worrell, 2003). However, in reality, studies on SMEs and their approach to energy efficient improvements show that some kind of barriers seem to prevent SMEs from achieving these lowered costs in practice, which goes against economically rational decision-making (Simpson et al., 2004; Sorrell, 2004; Jaffe and Stavins, 1994; Thollander and Ottosson, 2010; Rohdin and Thollander, 2006).

In fact, rationality is often constrained, as actors usually behave in accordance with something that is termed “bounded rationality” (Sorrell, 2004). Bounded rationality means that economic decisions that are made by actors are affected by factors such as lack of time, split incentives, imperfect information, and information asymmetries, which leads to sub-optimal economic decision-making (March, 1994; Sorrell, 2004). The concept of bounded rationality affects policy making and policy programs because their focus is then on helping local industry to overcome these aspects.

Bounded rationality is used to explain why cost-effective energy efficiency measures² are not always implemented, and why there is an “energy efficiency gap” between the calculated (i.e., anticipated or promised) and actual consumption of energy (Jaffe and Stavins, 1994; Hirst and Brown, 1990; Sorrell, 2004). Energy policy-makers, however, tend to neglect this gap, which leads to a mismatch between formulated policy objectives and actual outcomes (Foxell and Cooper, 2015). One theory that is used to explain the existence of an energy efficiency gap that hinders improved energy efficiency is the barrier model (Sorrell et al., 2004; Hirst and Brown, 1990; Weber, 1997).

Sorrell et al. (2004) define a barrier as “a mechanism that inhibits a decision or behavior that appears to be both energy efficient and economically efficient.” The barriers examined in the present study include behavioral, organizational, and economic barriers (Weber, 1997). In a recent study, it was found that SMEs experienced many different barriers, causing them to encounter great complexity when they tried to achieve energy efficient measures (Meath et al., 2016). These barriers can differ, depending on sector and regional-specific conditions (Sorrell et al., 2004). It is important for municipalities to assess these barriers and adopt effective energy efficiency programs, and not to bundle different local SMEs into the same type of project. Municipalities should focus on trying to match SMEs with others that experience the same type of barriers; thus, regional and sector-specific policy programs are needed in order to reach specified goals (Ramirez et al., 2005).

Barrier theory is not without its opponents; for example, Lutzenhiser (2014) views the topic of barriers in another light. This criticism takes as its starting point the widespread recognition that people do not adopt technology at the levels that are suggested to be cost effective, according to economic theory. Thus, the argument continues, framing unrealized energy efficient improvements as being due to barriers will impose conceptual limitations on addressing an efficiency problem. Lutzenhiser also argues that a too-simple picture results if municipalities view actors as rational, attempt to understand why people do not behave in a rational way, and/or offer stimuli in order to lower the energy gap and encourage SMEs to adopt energy efficient

² A cost-effective energy efficiency measure is defined as an investment that decreases the use of energy and that is considered to be cost efficient according to the company's investment criteria.

technologies as they “should” if they were rational. Rather, this picture must be broadened to include an understanding of actors in market systems and a perspective of barriers “not as simple evidence of intervention failure but as constitutive features of social structure and social action” (Lutzenhiser, 2014).

Barrier theory has affected my thesis in two ways: I used barrier theory in article 2 because this theory is so prevalent in the discourse on energy efficiency on EU, national, and municipal levels. In addition, both municipalities focused exclusively on barriers, rather than drivers, in their projects. The barrier framework also helped me to discuss with SMEs how they perceived problems and opportunities to work with energy efficiency in their organization. However, in article 3, I wanted to move beyond the barrier conceptualization in order to gain a deeper understanding of what was actually happening within the SMEs and how it was possible to influence their work with energy efficiency. The results from article 2 were an important starting point for article 3 and, later, for article 4, where I move toward a practice-oriented way of looking at energy efficiency in SMEs.

Many of the theoretical concepts that emphasize notions of the energy gap and barriers start with a perspective of energy as a resource or object that is independent of social and cultural factors (Shove, 2017). In this way, two parallel worlds are created. The first parallel world, which can often be seen in policy programs, is an abstract world that is governed by economic rationality, where energy efficiency means reducing the kWh/year or the cost by using new technology. Viewing energy efficiency in this way limits the options that are available for influence and change because much of the behavioral aspect is left out (Moezzi and Janda, 2014). Therefore, we should conceptualize energy in a different way that takes into account the social practices of actors in their everyday work (Shove, 2017). This other world is more complicated; it has a social practice dimension in which SMEs and their day-to-day operations exist (Lutzenhiser, 2014). Shove (2017) argues that we should turn our thinking around, and instead ask an important and central question: “What is energy for?” By asking this question, she argues, we take a social view that emerges from and is defined by a social practice in which energy is embedded in social life. Shove (1998, 2017) argues for an alternative approach in which energy supply and energy demand are viewed as part of everyday use, rather than viewing energy in isolation from the practices it is a part of.

This notion of placing energy efficiency within a social context rather than abstracting it from everyday use affects work with improving energy efficiency. For example, technological developments that improve performance in one dimension often have consequences for other dimensions (Shove, 2017). Therefore, we should evaluate energy efficiency depending on the context, conditions, and culture (Lutzenhiser, 2014). This perspective can have a large impact on SMEs, depending on how they view energy. For example, is it a part of an SME's core business or brand to be energy efficient, or is the cost of the SME's energy use small compared with the total cost? By viewing energy as something that is dependent on other factors, the simple picture of an SME and its energy audit report, leading to the installment of energy efficient technology, is expanded to include many more actors—both human and nonhuman. If this view is not taken into consideration, it will be difficult to close the energy efficiency gap (Gram-Hanssen and Georg, 2018) and make policy programs effective. In other words, policy programs that focus only on a certain number of kWh/year as an output will miss the point of working with energy efficiency. Instead, energy efficiency must be seen as part of a larger puzzle, where the number of kWh/year is embedded in everyday practices and is affected by budget restraints, time, knowledge, and so forth.

When arguing that energy efficiency must have a social dimension, it is important not to forget technology itself. Therefore, if climate change policies are to make a difference, we must cause improving energy efficiency with the aid of technological solutions to be a part of the messy world of different practices that determine energy demand (Shove and Walker, 2014). Since human actors are not only involved in the end-use phase of energy use, but also in the design, construction, introduction, and installation of new technologies, policy programs should consider alternative ways to work with the material and social aspects of different operations, and alternative ways to provide guidance and support to the involved actors (Gram-Hanssen and Georg, 2018).

Although barrier theory provided theoretical insights that were appropriate for the explorative nature of article 2, I found this theory less helpful for my later papers. While articles 3 and 4 were also influenced by the barrier discourse, I was more guided by the idea of practice theory; that is, by the concept that energy is used in relation to a social practice, and that in order to have a deeper understanding of energy efficiency in SMEs, it is necessary to understand the social

context in which energy use is embedded. I am not performing a social practice analysis; however, I was influenced by this perspective and by its emphasis on the social context rather than on energy efficiency *per se*.

Knowledge and information

As noted in the previous section, barriers hinder SMEs' implementation of cost-effective energy efficient measures; these barriers often take the form of lack of knowledge and time (Backman, 2017; Trianni et al., 2013). One type of response to this situation can be seen in various policy programs that aim to promote increased energy efficiency measures by focusing on changing the products and processes in SMEs (Biggart and Lutzenhiser, 2007). These policy programs frequently provide advice through energy audit reports and investment plans in order to help SMEs overcome their barriers (Backman, 2017). This advice or information often takes the form of explicit knowledge, which may include lists of available technologies such as new and improved forms of lighting and lighting design, ventilation, heating, air conditioning, or control systems that will reduce energy use and costs if they are installed or used (Biggart and Lutzenhiser, 2007).

Even though the implementation of the measures provided by energy experts and investment plans would lower costs for SMEs from a rational economic perspective, SMEs do not seem to do as much as they could, and many opportunities to realize energy efficiency measures are not explored (Sorrell et al., 2004; Jaffe and Stavins, 1994). According to Biggart and Lutzenhiser (2007), this is because social and cultural dimensions are not taken into account when making recommendations for SMEs. This can be seen when energy experts provide energy audit reports, for example, as such reports often do not take into account the research showing that technical change requires dialogue and/or conversation between different actors in addition to explicit information in order to work (Lundvall, 2017). In other words, SMEs do not make decisions regarding energy efficiency in a vacuum by themselves; their decisions are influenced by social relations and considerations from both internal and external actors. In this way, beliefs, social structure and norms, culture, power relations, and other non-economic considerations can have a large impact on energy decisions, depending on how a community or network is organized. Including a social dimension can therefore add important insight to the energy efficiency debate (Biggart and Lutzenhiser, 2007; Shove, 2017;

Shove, 1998). The inclusion of non-economic considerations when devising a policy program is important for future policy programs; without such considerations, there is a risk that such programs will not fulfill their intended goal (Biggart and Lutzenhiser, 2007).

Gaining and creating knowledge requires more than simply gathering and disseminating information. Nonaka and Takeuchi (1995) and Polyani (1983) argue that knowledge consists of two parts: explicit and tacit knowledge. Explicit knowledge is often expressed or codified in reports or documents in a formal matter through words and numbers, and is more easily diffused between actors (Terzieva, 2014), such as between energy experts and SMEs. Tacit knowledge, on the other hand, involves skills and understandings that have been internalized and that cannot be written down; such skills have a practice or learn-by-doing dimension. In order to gain this type of knowledge, personal experience, practice, imitation, storytelling, and sharing of best practices and lessons learned are often required (Lave and Wenger, 1991; Terzieva, 2014). Therefore, organizational learning is strongly related to activity and interaction during an attempt to solve a problem from an organizational perspective (Lundvall, 2017; Alvarenga Neto, 2007; Lave and Wenger, 1991; Arrow, 1971).

When knowledge is viewed from this perspective, the creation, use, and sharing of information within an organizational context becomes only a starting point for different initiatives (Alvarenga Neto and Souza, 2011). Knowledge needs to be embedded into organizational routines, habits, and mundane decision-making (Palm and Thollander, 2010). Thus, decision-making becomes both social and organizational, as the individual is replaced by the organization as a decision-maker through outcomes from social arrangements (Biggart and Lutzenhiser, 2007).

Tacit knowledge is often context dependent, and can be local in nature (Nonaka and Takeuchi, 1995; Maskell and Malmberg, 2006; Neij et al., 2017). The local nature of something should not be seen purely from a geographical point of view, such as in regional industry clusters (Lorenzen, 2001). It also means that learning occurs among and between people in close proximity. Close cooperation between people from different SMEs can provide them with a large and diversified knowledge base as well as with valuable experience, since this closeness can give them access to a shared base of resources, institutions, and social and cultural structures (Neij et al., 2017; Maskell and Malmberg, 1999).

Alvarenga Neto (2007) and Choo and Alvarenga Neto (2010) argue that policy programs should not primarily be about information sharing and transfer. Instead, they should focus on creating a platform for different actors that enables conditions for the creation of tacit knowledge (Alvarenga Neto and Souza, 2011). Such a platform would favor and encourage the creation, sharing, and use of knowledge at different levels of interaction (i.e., group, organizational, and inter-organizational levels). Important factors to consider are mutual trust, access to help, mixed formal and informal groups/communities, structure and shared goals, best practices, tools, and sharing spaces. Trust between actors is considered to be a critical factor that affects inter-firm knowledge creation and that plays a key role in the willingness of network actors to share and accept knowledge (Inkpen and Tsang, 2005; Lorenzen, 2001). A trusting environment is not only important between SMEs themselves, but also essential between SMEs, the project leader, and insourced energy experts when implementing the results of the energy audit and considering how trustworthy the new solutions may be. Using this kind of platform makes it possible to create an environment that better facilitates SMEs' capability for sense-making, knowledge creation, and decision-making (Choo, 1998).

Organizations such as SMEs act through network relationships with different actors that constrain, shape, and enable their actions (Biggart and Lutzenhiser, 2007). Therefore, a network is a possible type of platform for interactive learning, since a network structure has a positive influence on knowledge sharing (Chow and Chan, 2008). In a network, localized knowledge and information can be negotiated through face-to-face interactions between different actors (Pinch et al., 2003; Frances and Stevenson, 2018). This platform will support learning even better if it is guided by a bottom-up process through which it is possible to create and exchange knowledge and information through interactive learning-by-doing (Antonelli, 1996; Neij et al., 2017; Maskell and Malmberg, 1999). Although the literature agrees, in theory, on the usefulness of a platform for knowledge exchange between participants, the problem is how to create such a platform in practice. In fact, that is the topic of this thesis: to discuss and scrutinize two different forms of platform creation.

In article 4, I explore two different types of policy programs; one focuses on providing explicit information, while the other tries to create an environment that allows the SMEs to deal with the given information and create useful knowledge.

My background argument in article 4 is that knowledge in the form of external information does not automatically become knowledge that SMEs can put into practice when working with energy efficiency. Instead, the material aspect (i.e., the energy audit report) and the social aspect (i.e., working in networks) are intertwined and are dependent on practice and context.

Community of practice

The community of practice (COP) perspective, as presented in the work by Wenger and Snyder (2002), highlights the importance of engagement and participation at a local level in order to gain access to larger scale learning systems. In this perspective, knowledge is developed rather than transferred from actor to actor, and it is not possible to separate the formation and implementation of knowledge (Schön 2010). Wenger (1998) argues that learning cannot be designed but is something that happens when the circumstances are right. This viewpoint places more emphasis on designing social infrastructure, such as networks, to foster learning than on creating documents or curriculums containing the “correct” information (e.g., energy audit reports or investment plans). More recent contributions to research suggest that COPs can be cultivated and leveraged for strategic advantage (Wenger et al., 2002). Central to COP theory is the concept of less experienced members of the community learning through social interactions with more experienced members and with experts in a specific knowledge domain (Lave and Wenger, 1991). COPs should not be seen as only existing internally in organizations or companies; they can also be external to an organization and may consist of a group whose members regularly engage in sharing and group learning, based not only on company affiliation, but also on common interests, mutual trust, and collaboration (Dewhurst and Navarro, 2004).

A COP should be viewed as a mechanism through which knowledge is created (Brown and Duguid, 1991; Lave and Wenger, 1991; Wenger, 1998); in these COPs, negotiation, learning, meaning, and identity take shape under certain conditions (Wenger 1998). COPs are different from other communities because a COP’s knowledge is self-generating and self-maintained, and because knowledge creation is an intrinsic functional property of COPs (Adams and Freeman, 2000). Three practice dimensions can be identified that form the source of a COP’s coherence. Firstly, *engagement* is achieved by doing things together, such as discussing and producing artifacts.

Secondly, *imagination* involves constructing an image of ourselves, of our communities, and of the world, in order to orient ourselves, reflect on our situation, and explore possibilities.

Finally, *alignment* involves making sure that our local activities are sufficiently aligned with other processes so that they can be effective beyond our own engagement (Wenger, 1998).

COPs include members who contribute on different levels such as experience, expertise, age, personality, and authority within the organization (Roberts, 2006). Since COPs contain a social element, they are easily influenced by both internal and external forces. For example, management, local authorities, and experts can inhibit the will and ability of members in the community to engage effectively in a practice (Coopey and Burgoyne, 2000).

The type of work relations that exist during the existence of a COP play an important role in determining its success as a way of managing knowledge. If adversarial relations are created between members, experts, suppliers, and management, and if low levels of trust and strong hierarchical control are created, COPs will likely fail to be an effective means for knowledge creation. COPs work more effectively if the environment is harmonious and trusting, and if members are given a high degree of autonomy and flexibility. The COP approach is a way to explore how knowledge is created in a social context; in addition, it provides an alternative to knowledge-management tools that are more focused on the codification of knowledge (Roberts, 2006).

In article 3, I use COP theory to analyze why the network structure in case study 2 was successful. COP theory argues that a network structure helps to create knowledge through practice. Therefore, work with energy efficiency should be seen as a negotiation between actors with conflicting priorities and goals, which is transformed within a network (Frances and Stevenson, 2018; Latour, 1987). I use COP theory again in article 4, where I compare my two case studies and examine how and why different policy programs may have different outcomes.

In summary, my analysis of how municipalities can work with energy efficiency together with SMEs and other actors is based on theories of policy networks, energy efficiency networks, COPs, and barriers to energy efficiency.

Method

In this chapter, I describe my research design and the process of collecting my material.

A hermeneutic approach

This chapter provides the reader with a deeper reflection on which, how, and why different methods underlying the collecting of the material for this thesis were used, since it was not possible to provide this explanation in depth in the individual papers. Here, I describe the methods that were used and identify where different methods were used in the thesis.

My research has not been as linear as it may appear in this thesis. This thesis did not start with a predetermined aim, research questions, or even a research design. In fact, the original research idea was discarded fairly soon in the research process. At first, it was decided that the public procurement of energy efficient technologies and possible innovations from case study 1 should be studied. However, this proved to be impossible because no public procurement had been done and no new innovations had been created. Therefore, only the material that was collected early on in the process—regarding how SMEs could come together and procure technical solutions in order to lower transaction costs—was kept. It was also clear that it was necessary to supplement this data with new material as the thesis matured.

The process-oriented practice of coming up with four articles resulted from my attempts to find some interplay and a common theme between my material and various theories, questions, and problems. The methodology I used for my research can best be described as an interaction between theories and the material I obtained from different sources throughout the research process. That is, I went back and forth between theories and my material as I moved from more general to more specific knowledge regarding my overall purpose. The process was thus hermeneutical in nature (Andersson, 1979; Thorén, 1991; Patton, 2002). Hermeneutics is about interpreting, understanding, and conveying peoples' perspectives on different phenomena (Kvale et al., 2009), and it is well suited for studies that are based on interviewees' perspectives and interpretation. An important part of hermeneutics is the use of different sources such as documents, interviews, and quotes in order to support the interpretation and to see whether the different

sources contradict each other, or whether they agree and form a united picture. It is also important to pit earlier research against the new material in order to strengthen the conclusions that the researcher makes (Fejes and Thornberg, 2015). This hermeneutically inspired way of doing research is most likely why the thesis ended up being what it is today.

Case study approach

The aim of this thesis is to deepen our understanding of how municipalities can support local SMEs in their work with improving energy efficiency in order to bridge the energy efficiency gap. This is done via case studies of two policy programs in two municipalities located in two different regions in Sweden.

I am interested in getting answers to “how” questions in my study, and the literature on methodology argues that a case study approach is suitable for this type of research (Yin, 2009; Patton, 2002; Merriam, 1994). The case study as a research method is considered to be valuable because it enables the researcher to study specific cases in depth. This allows the researcher to look more closely at special areas of interest and at how contextual factors can matter (Yin, 2009; Patton, 2002). Case studies have been used in many areas; not only in the social sciences, but also in other fields. Examples include environmental studies, social work, education, and business studies (Johansson, 2003). Cases that are studied may involve individuals, groups, programs, organizations, or communities, among others (Patton, 2002). For this thesis, case studies were a relevant method for obtaining a deeper understanding of how municipalities worked differently with local SMEs and why they chose different strategies.

Case 1

This project started in 2011, with a municipal board decision about sustainability that aligned with the municipality’s environmental vision. This vision policy document considered two areas—local industry and quality of life—to be particularly important. From this vision, a project idea (originating in the municipality’s environmental office) took form with the aim of addressing energy efficiency and local industry. Previous experience with this issue showed that it was difficult to get local companies to invest in energy efficient measures, even though these were potentially cost effective. Having ambitious environmental goals, the municipality gave the environmental office the mandate to proceed with the project, which was named Energy-

Driven Business. This project involved not only an environmental focus but also the idea that increased energy efficiency would lead to an increase in the competitiveness of local businesses. The group of companies involved in the project originally consisted of 200 companies. The number of companies was then reduced in the second phase, as the municipality chose 60 companies for the project. The project received funding from the Swedish Energy Agency (SEA) and was intended to focus on identifying and implementing energy efficient measures in the companies. A wide range of companies was chosen, including farmers, garden centres, grocery stores, and smaller industrial manufacturing companies.

The project focused on improving energy efficiency in micro- and small-sized enterprises that used 500 MWh of total energy end-use per year or less. In this municipality, local business is dominated by industrial manufacturing, although trade is also important.

One starting point for the municipal project was the earlier experience that had been gained regarding how companies seemed to be more concerned with other capital investments than they were with energy efficiency measures. At the start of the project, it was calculated that several of the companies could save up to 20% in energy costs with the use of simple and cheap measures, mostly to support processes. To overcome this apparent paradox, the municipality worked to motivate the SMEs and tried to lower thresholds such as lack of time and knowledge. This was done by providing free energy audits and helping the companies develop investment plans. The municipality also provided an engaged project leader who was passionate about energy efficiency and who, by his enthusiasm, tried to help the companies move forward. The active part of the municipal project lasted from 2012 to 2015.

Case 2

The second case involves a municipality that began supporting local SMEs with energy efficiency work in 2009 and continued doing so until 2016. This case involves 22 SMEs, 21 of which completed the project. These SMEs invested in energy efficient measures for processes such as ventilation, lighting, heating, and production. The original idea in 2009 was to lower energy consumption in order to address rising costs and decreased revenues, due to the economic crisis at that time. The project was based on a working model in which actors cooperate in a network to lower their energy use. This network consisted of different SMEs and energy experts, along with a municipal representative who coordinated the project.

In this model, the municipality began by contacting the local business association with the idea for a pilot project. The municipal project coordinator was then invited to briefly speak about the idea at one of the business association meetings. After this meeting and its subsequent discussion, three of the companies sat down with the project coordinator and decided how the working model should be structured. For the municipality, it was important that the local SMEs be involved in the whole process and be given the opportunity to voice their opinions. For the first nine SMEs in the 2009 pilot project, a common goal of 30% reduction of their idle energy use was decided on as a reasonable target. At the end of the project, these SMEs had, on average, decreased their idle use of energy by 33% (where 7% was the lowest and 85% was the greatest decrease). For the SMEs in later projects, a common goal of between 15%–20% was generally agreed upon. This goal was generally reached, and was increased in some cases to around 30%.

The SMEs participating in the network were offered training, tools, and support in their process so that they could do an energy audit together and work with energy efficiency on their own. The goal of the project was to enable the involved SMEs to become “knowledgeable doers.” That is, the SMEs were supposed to gain knowledge and skills for working with their own energy use both organizationally and technically. The focus was on the SMEs’ practical work with energy efficiency during the project and after its completion. The networks usually consisted of five to nine locally based SMEs from different sectors; together, they determined a network target for increasing energy efficiency. The overall cost for a participating SME was generally around €1,000 for the network operating period. The municipality supported the project by providing around €1,500–3,000 per company. At the end of this period, each SME decided whether or not to continue working with the network. These costs covered support from energy experts and the project leader, 10–12 network meetings (1 half-day meeting/month), and a final assessment of the monitored results. The focus was always on making the SMEs practice what they learned, thus increasing their knowledge, and on having them then share these experiences with each other in an informal network setting.

Selection of cases

In this thesis, I present the results of the two case studies above, and discuss how the two municipalities supported the local SMEs’ work with energy efficiency in different ways through their policy programs.

From the inception of this thesis, the area of study and the municipality (case study 1) were partly decided for me, since my research project was financed by an external research foundation—the SEA. The SEA’s focus was on case 1, the Energy-Driven Business project that aimed to help local companies increase their rate of implemented energy efficient measures by providing free energy audits. After a while, it became clear that the original idea for the study was not feasible because the municipality in question decided to proceed in a different direction with the project, thus making the initial research questions in the proposal invalid. As a result, I had to go back to the material that I had already collected on the Energy-Driven Business project. This material came from interviews with the environmental strategist and the environmental manager, and from observations at project meetings with involved people from the municipality. This material allowed me to look for possible new research questions to work with.

My research was also influenced by input from project meetings at the SEA that I was invited to and that I attended as part of my study of case 1. The SEA-led project involved municipalities that had signed up to work with energy efficiency in industry. At these meetings, I met and discussed energy efficiency with the municipalities involved in the SEA project, and talked to energy experts working with energy audits. Through broad discussions of the different problems related to getting SMEs to work with energy efficiency that the municipalities had experienced in the project, and with my previous material from case 1, my thesis slowly began to take shape. I was especially influenced by my discussions and informal talks with an external consultant who had worked with the municipality that became my case 2. This consultant was a former project leader for the municipality in case 2. This municipality had used a different type of model to support SMEs than the one that was used in case study 1, which I found interesting.

These discussions led to my choice of this municipality as my case study 2, and eventually led to material for two of my articles (articles 3 and 4). I chose this case because, at this point, it was clear that the most interesting research avenue would be to compare these two municipalities and examine how they supported local companies in different ways in the companies’ work with increased energy efficiency. The former project leader also found this comparison interesting, and gave me access to the official documentation of the SMEs’ final results and of how the model was used. The project leader was able to provide me with contacts for the energy experts who had been involved.

Both municipalities used their own locally developed model, with the purpose of influencing work with energy efficiency in local businesses. I first studied the two models separately (articles 1–3) and then compared them (article 4), in order to gain independent knowledge of each before comparing the two to gain new insights. To be specific, articles 1 and 2 are about case study 1, article 3 is about case study 2, and article 4 compares the two cases (see Figure 5).

Selection of interviewees

For case study 1, the chosen target group for the questionnaire had already been decided within the boundaries of my research proposal. A list containing contact information for the 60 companies that were involved in the project was provided to me by the municipal representative, who was also the project leader. I first contacted these 60 companies by email, by providing a short introduction to my research and by describing what I would like to talk to them about. I then followed up by phone. In the end, 27 companies responded to my emails and phone calls and were subsequently interviewed. I also interviewed both the municipal representatives in the environmental department who were involved with the project, and one energy expert who performed some of the energy audits in the project.

At the companies, I interviewed the managing director, the owner, or the person who was responsible for that company's energy work. The main criterion for an interviewee was that he or she had been involved in the relevant municipal project. Of the respondents, 22 answered all my questions, including the questionnaire. The other five respondents did not want to answer the questionnaire and only gave short answers to my more general background questions. Telephoning people and going through the questions, compared with sending them a survey, was important in that it gave me the opportunity to clarify the questions or the content of the responses, and to explain why the questions were being asked.

The collection of case material for case study 2 was different, mainly because the focus of the research questions differed, but also because the type of available data was different. Company selection was based on which companies had participated in the different municipal programs starting in 2009. Data was gathered through interviews with the former project leader, SMEs, and energy experts. The project leader had also worked with case 1, and therefore had insight into both projects. I used the interviews as a complement to the available documents and as a source to help me understand how the model

worked and where influences came from. I carried out several interviews with the project leader. The first interview was a regular interview, whereas the follow-up interviews were for the purpose of clarifying something or asking about something specific. In addition, I interviewed three companies and two energy experts that had been part of the energy efficiency projects in the municipality. In total, I conducted ten interviews from 2016–2018.

Data-collection methods for the case studies

In a case study, data can be collected in many forms and from many sources, including observations, interviews, documentary data, statistical information, impressions, and statements (Patton, 2002). See Figure 5 for an illustration of how different sources were used in this thesis.

In my studies, I used interviews, observations, and documents to gather data (see Table 1). In the articles, different methods had different uses and therefore differed in importance. I used a combination of methods because a combination can provide both a wider picture of the cases and a deeper understanding of the factors that influenced the processes of interest. For example, interviews can be used to complement documents and to answer questions that the interviewer has after studying the documents.

The use of different ways of gathering data is often called triangulation. Denzin (1978, cited in Miles and Huberman, 1994:267) classifies four kinds of triangulation: by data source (which can include people, times, and places), by method (observation, interview, documents), by researcher (use of different researchers in a study), and by theory (use of several theoretical perspectives). For this thesis, I used methodological triangulation in order to obtain corroboration between the different types of data I collected. I did this in order to reach a high level of reliability in my research, by comparing the results from two or more methods (Miles and Huberman, 1994).

Participatory observations

Collecting what people say through interviews or through documents are two ways in which data can be collected. Another way that can complement these data-collecting methods and provide more depth into the complexity of many situations is to participate in and/or observe the phenomenon in question (Patton, 2002).

Observational data can help the researcher to understand a program or policy in a different way by giving insight into things that are not caught by other means of data collection (Patton, 2002). Observations are often made at meetings, gatherings, or events where the researcher can observe particular people or processes in a more direct way (Alvesson and Kärreman, 2011). This type of data gathering was important to me because I study social networks, and social processes are difficult to capture by performing only interviews and/or document studies. I used this data-collecting method for the first case, in which I was more of an observer and less of a participant than in other types of participatory studies, where actual participation in the process is important.

For data regarding case study 1, I sat in on two different types of meetings. First, I participated in six meetings between SEA and the municipalities that were involved in the project. In these meetings, much of the discussion centered on problems the municipalities had with getting local companies interested in the project, and on how the project leaders should analyze the energy audits that the SMEs had received in the project. Second, I observed two meetings between the municipality in question and local suppliers. The municipality invited suppliers to discuss possible technical solutions that the individual SMEs needed, and to determine whether they could come up with an economic proposal to support the SMEs' decision-making process regarding energy efficient measures. Another reason for these meetings was that the municipality wanted to involve as many of the local businesses in the project as possible. Some of the material from the initial meetings that I attended was of no direct use because the original aim of the project changed, and some of the municipality's ideas were later found to be difficult to go ahead with. However, attending the meetings was an excellent way of observing how the municipality worked with other municipalities and with local SMEs, and how problems and tensions could arise.

For case study 2, I made no observations because the local SMEs under study in this municipality were already finished with their energy efficiency work. Therefore, this case is based on document studies and interviews. The way in which I used observations aligns with the work of Alvesson and Kärreman (2011), who argue that observations are an important data-collection method when studying practices or discourses in social settings, and are an excellent complement to interviews.

The impressions and information I took with me from these observations were valuable to my later research. This was particularly true in regards to the practice dimension—how the municipality in the first case worked on the project, and how other actors such as suppliers, experts, and SMEs responded to the handling of the project. These insights later influenced my choice of theory and what to focus on in my thesis.

Figure 5 How different methods were used in this thesis

Document studies

According to Patton (2002), records, documents, and archives can be a rich source of information for the researcher. For example, documents can provide information about things that cannot be observed, and can also be used to investigate what happened in a project or event that occurred before the study began. This is how I used the documents that I had access to. Since the SMEs that I chose to study in case study 2 had already finished their involvement in the different projects, documents gave me a chance to see what the SMEs had done in practice and to grasp the reasoning behind how they worked. The documents also gave me food for thought that I later used as inspiration for my observations and interviews in case study 2. Unlike case study 1, most of the collected data for case study 2 came from different types of documents.

This case had much more written information about the projects than case study 1, in the form of both news articles and project reports.

In case study 1, most of the documentation was related to the energy audits that the SMEs had received; no documentation existed regarding the results from the audits or any final results from the project. For case study 1, it was also impossible to gain access to many of the documents that had been collected or created by the municipality, due to a confidentiality clause between the municipality and the SMEs. In case study 2, more documentation was available, and it was of a more varied kind. In addition, there was no problem gaining access to these documents. The documents for case study 2 consisted of background material, newspaper articles, and final reports on saved energy and energy efficiency measures that had been taken by the involved companies. The newspaper articles were found on the Internet, whereas documents showing the results were provided to me by the project leader. The latter documents were rich in detail and allowed me to see how much work the involved SMEs had actually done, their future energy efficient measures, and how these related to the different energy audits that had been done at the companies.

The documents have three main roles in my thesis: They provided me with background material on the studied cases that I used to develop my questions; I made use of them when analyzing and comparing the two cases (article 3 and 4); and they allowed me to compare my results with the interview material. In this way, the documents and interviews complemented each other.

Structured and semi-structured interviews

Much of the data for this thesis comes from interviews that were made in person or by phone. These interviews provided background information on the different projects I studied in the two cases. I also used them to obtain individual persons' views of the projects. I used structured or semi-structured interviews (Alvesson, 2011; Rubin and Rubin, 2012). It was only for the barrier article (article 2) that I chose a more structured form of interview. For this article, I was interested in receiving more specific information on barriers, and wanted to be able to compare my results with those from other barrier studies. Therefore, I used a questionnaire that was based on a survey that had been used in earlier research (Rohdin et al., 2007; Thollander and Ottosson, 2008). I used the same structured and fixed set of questions for all 27 companies. The questions were always presented to the respondent in a fixed order, making it possible to replicate the interview and, later, to

compare the information from all the interviews. Using a fixed set of questions is important if the researcher is unable to interview the informant more than once, and is therefore not likely to repeat the interview, which was the case for me. Presenting the questions in a fixed order also helps to limit so-called context effects, since preceding questions can influence the interpretation of subsequent questions. This can in turn influence what information respondents share with the researcher during the interview (Patton, 2002; Schwarz and Strack, 1990). However, it was still possible to clarify the questions, as explained above. I also asked the informants for clarification or to explain further when I did not understand their response.

In order to evaluate the answers in the questionnaires, a Likert scale was used, ranging from 1 to 5: (1) disagree, (2) partly disagree, (3) neutral, (4) partly agree, and (5) agree. This questionnaire enabled me to investigate, by asking specific questions, what factors were perceived as barriers to energy efficiency by the local SMEs in case study 1. As noted earlier, I chose to use this questionnaire in order to be able to compare my results with earlier research that had used the same form regarding barriers to energy efficient measures (Rohdin et al., 2007; Thollander and Ottosson, 2008). As a result, I was able to discuss my findings in a more general way. For a more thorough presentation of the questionnaire, see article 2, appendix A.

In the semi-structured interviews, I used an interview guide. However, these interviews were more similar to a conversation than to a situation where all the questions were asked in a certain order (Kvale and Brinkmann, 2009; Rubin and Rubin, 2012). I used open-ended questions in order to allow the interviewees to give their story without influencing their answers, as much as possible. My questions were sorted into themes that were of interest to me, as follows: (1) what was done in the project, (2) what the project provided to the involved actors, (3) why they participated in the project, and (4) what hindered their work with energy efficiency. In this way, I was able to stay close to the topic while still getting information on my topics of interest, without limiting the respondents' answers too much.

Most of the interviews were done over the phone; it was only with municipal representatives and the project leaders that I met and conducted interviews in person. My phone interviews lasted around 15–45 minutes, depending on how willing the respondent was to talk to me. For the structured interviews that I did, a form was filled in during the phone conversation.

The interviews I performed face to face lasted from 30 minutes to 1.5 hours, depending on whether it was a first-time interview or a follow-up interview. I sometimes interviewed people in more than one way; for example, by doing a face-to-face interview first, and then doing a follow-up interview by phone. I complemented the interviews by taking notes during and after the interviews. These notes were used to record insights and to note questions that I later asked other interviewees in order to compare their views.

The results from the interviews differ in terms of outcome and amount of data that could be gathered. The municipal representatives, project leaders, and experts were always interested and willing to take the necessary time for me and my questions. The SMEs were a completely different story. Many SME representatives were busy and rather reluctant to talk to me. I had to speed up interviews sometimes because I felt that the interviewees were in a hurry and that I was losing their interest. Some of the SMEs that I wanted to interview declined to participate, while others answered only one or two of the questions on their experience with a municipal energy efficient project. On the whole, however, the SME representatives that did participate in the interviews were very interested and were surprised that no one had called them earlier; this led to very pleasant and informative talks.

Out of all the interviews that were analyzed in this thesis, 11 semi-structured interviews concerning case study 1 were not conducted or transcribed by me, but were performed by other researchers in my department. Seven of these interviews involved politicians and officials from the municipality, and four interviews involved people from other municipalities that had worked with local businesses and that were interested in applying the municipality's model. These interviews were conducted without me because the project that I was involved in started before I became a doctoral student. However, since I had access to these interviews and they concerned case study 1, I made use of them along with my own data. The interviews were conducted and transcribed but had not been analyzed before I started the project; thus, the analysis was handed over to me. These interviews, which existed in the form of a transcription document, provided background material for my work and were then analyzed along with the material I gathered for case study 1.

I chose to keep the interviewees and the studied municipalities anonymous because the interviewees have ongoing relationships with each other.

I also felt that omitting names would make it easier to open up the conversation and would allow for critical reflections from the interviewees. In addition, I chose to keep the cases anonymous because of the differences in the outcome of the projects, in terms of realized measures. This information could become sensitive and might lead to negative feelings in the future. Thus, I mentioned only the interviewee's or other respondent's position when using quotations or providing a reference, since position is important for context.

Table 1 Summary of methods and the amount of work done in the case studies

Time period:	Case study 1 (2014–2016)	Case study 2 (2016–2018)
Interviews	27 interviews with SMEs involved in the project; 1 interview with the environmental manager; 1 interview with the environmental strategist; 1 interview with an energy expert in the project 11 interviews done by other researchers. Analyzed by me	3 interviews with the SMEs involved in the project; 5 interviews with the project leader; 1 interview with each of 2 energy experts active in different areas
Documents	1 municipal policy document; 3 official documents from the SEA	22 final reports from the projects; 1 municipal document; 2 official documents from the SEA
Observations	Participated in 6 meetings between SEA and the municipalities that were involved in the project; participated in 2 meetings with municipal representatives and suppliers	None

Analysis of the cases

The literature on qualitative research argues that there is no standard way to analyze interviews or perform content analysis. Instead, the researcher should look for ways that help him or her to gain more knowledge about the phenomenon that he or she is studying (Kvale et al., 2009).

I used meaning condensation to analyze the material from the interviews (Kvale et al., 2009; Malterud, 2012). To do so, I listened to each interview, sometimes two or three times, and condensed passages from the interviews into shorter statements. I then sorted these statements into specific themes in relation to the theories in question (Kvale et al., 2009). This process was always performed right after the interviews, while the interview was fresh in my mind. I also recorded interesting quotes for later use in the articles. Finally, I compared my notes in order to make general conclusions and look for interesting discrepancies. Throughout the research process, as my insights increased, I returned to my material to see if I could find something new that would add to my analysis. As a result, I sometimes needed to make complementary phone interviews to clarify an issue.

To ensure the validity and reliability of the interpretations in my analysis, I checked the statements in the interviews against other interviews and against the documents, as far as possible. I also discussed some of my preliminary results with the people involved in the projects. This process of going back and forth between different sources followed the hermeneutic approach (Sandberg, 2005; Kvale et al., 2009). In this way, I was able to create a coherent interpretation that aligned with my view of the results and with the views of the people that were part of my study (Sandberg, 2005).

Reflections on methodology

I used interviews, observations, and documents that expressed the subjective views of people from different backgrounds, including my own, so there is an inherent bias that could affect my analyses. To minimize this bias, I tried to use methodological triangulation (Miles and Huberman, 1994) as much as possible in order to obtain a reliable and valid result. I chose not to transcribe the interviews I conducted or make use of a professional service to do so because, as Kvale et al. (2009) argue, interviews are not transcriptions but living conversations.

When performing my analysis, I did not want to add another subjective filter; instead, I wanted to stay as close as possible to the source and to be part of this living conversation by listening to the original recording. When listening, however, I did write down quotes and interesting parts to include in my analysis. Another reason for not transcribing my interviews was that I was not doing a text analysis, in which pauses, repetitions, changes of tone, or emotional expressions are relevant for psychological interpretations (Kvale et al., 2009). However, the 11 interviews that had been conducted by others in the project were transcribed by them, and I used this transcription in my analysis.

When working with the documents under study, I kept in mind that they were written by people and were therefore subjective, with possible underlying reasons for having being written. For example, the documents from the SMEs and municipalities showing the final results of the projects could have made the results appear better than they were in reality, in order to make the projects appear more successful. Therefore, I followed an iterative process of correcting (Sandberg, 2005) by comparing different sources of knowledge.

It is possible that my observations in case study 1 may have affected the project's results. However, during this process, I took notes of the situation but did not participate in the conversations that went on, so the interaction between me and the other participants was minimal. In addition, the Energy-Driven Business project was nearing its end, so the agendas for the meetings and the suggested work order were already established. I was also not asked to contribute to the discussions or to express my opinion on areas of interest, so my influence on the ongoing process and end results must be seen as negligible. I kept my participation passive during the meetings so I could observe without influencing the process or the people involved. This was made easier for me because I was presented by the project leader as a researcher who was interested in the project but who had no technical knowledge or previous experience of similar projects that were relevant for the discussions.

In summary, I used a case study approach with two different cases for my thesis. These cases were chosen in line with what Flyvbjerg (2006) terms "information-oriented selection." That is, I selected these cases because of their expected informational content.

In information-oriented selection, the information can be about a significant difference, such as a type of process or outcome. One might argue that it would have been better to examine many more cases and companies, both from a validity point of view and to make the study more generalizable. However, performing statistical research often begins with a hypotheses and a set of parameters to study. In this thesis, I had no hypothesis to start with and wanted to keep the question of what parameters were important as open as possible. Therefore, I chose a more explorative research design that would allow me to go deeper into the two cases under study.

The companies to be studied in the two cases were predetermined, since only these companies had participated in the different energy efficiency projects. It is possible that my results would differ if I had been able to choose other companies, to examine a more homogenous group of companies, or to interview the companies that I could not reach or that were uninterested. In order to overcome this problem and increase the reliability of my study, I was careful to compare my results with those of other studies on the implementation of energy efficiency measures (Rohdin and Thollander, 2006; Thollander and Ottosson, 2008; Koewener et al., 2011). My results showed similarities to their results, thus strengthening my claims and increasing the reliability and validity of this thesis.

Summary of articles

This chapter provides short summaries of the appended articles. I present the aim, the main theoretical concepts, and the main results that are relevant to the concluding discussion.

Article 1

Title: “Policy network creation as a driver of the energy efficient industry”

International Journal of Energy Sector Management, Vol. 11 (2017)
pp. 143–157.

Co-authored with Professor Jenny Palm

Article 1 is about a Swedish municipality that has begun to support energy efficiency work in local businesses by means of a network approach, in order to increase the amount of implemented energy efficient measures. The paper’s aim was to analyze the lessons learned and the practical implications of using policy networks to implement energy efficiency measures in local businesses. In my analysis of this municipal network, I used four hypotheses regarding how policy networks develop:

- 1) **Growth and spread of a generalized belief:** Actors in a network need mutual understanding regarding what is perceived as good, bad, effective, desirable, and so forth, if they are to prioritize their actions and organize a solution to a problem. How did the municipality act to achieve mutual understanding?
- 2) **Precipitation factors:** The network under study was initiated by a political decision, which would generally indicate less focus on specific problems. How did the problem definition evolve in the network?
- 3) **Mobilization of actors:** Self-organized policy networks are more likely to contain committed actors. How has the fact that the studied network was initiated by the municipality affected the engagement of the network members?

- 4) **Coordination and control:** Networks are subject to social control, which is related in turn to coordination. Control emerges from processes of interaction between individuals. What kinds of control have the involved actors been discussing? How has this discussion affected the speed and extent of the collaboration's evolution?

The study is based on interviews, participation in meetings, and document studies. The results from the study show that the network had a too-broad problem definition. This led to the local businesses not identifying themselves with the network goal, and further led to problems with creating value and reasons for implementation among the involved actors. The companies' involvement was based on passive participation, in which they only received information; the network did not increase much-needed knowledge or develop necessary skills. The network was unable to use a social control mechanism because there were few company-to-company meetings. The result was that the policy network proved to be a weak policy-implementation tool for the municipality. However, the conclusion is not that the policy network, as a platform, is a bad policy tool. Rather, the conclusion is that it is important for a policy network to function well according to all involved actors in order to facilitate the successful implementation of policy goals.

Article 2

Title: "Barriers to energy efficiency in Swedish non-energy-intensive micro- and small-sized enterprises: A case study of a local energy program"

Energies, Vol. 10 (2017), pp. 1–13.

Article 2 examines how Swedish municipalities can support local micro- and small-sized enterprises in improving their energy efficiency. Using barrier theory, it also investigates the existence of different barriers to the implementation of energy efficiency that these companies experience in their work with energy efficiency. The existence of barriers is one possible explanation of why companies do not do more to implement cost-effective energy efficient measures, which leads to a gap between potential and implemented cost-effective energy efficient measures. With the use of a survey, the barriers that were found in this study are compared with the results of previous studies on barriers.

After relating this empirical case study to the theoretical barriers outlined in the text, this study found that the major explanatory factors related to the non-implementation of cost-effective energy efficiency measures among micro- and small-sized industrial enterprises were: bounded rationality (lack of time and/or other priorities), split incentives (having other priorities for capital investments), and imperfect information (slim organization and lack of technical skill).

This paper also found support for the idea that voluntary municipal energy efficiency programs should be flexibly designed and implemented in order to accommodate the many and various barriers. Factors that drive companies' work should be emphasized and barriers should be identified upfront so that policy programs can be tailored to the often-varied needs of SMEs. Finally, it was found that context and something more than information is needed in order to support companies in their struggle with energy efficiency. A forum for discussion and questions must be created so that the companies are actively involved in the process and are not simply silent bystanders.

Article 3

Title: “Local knowledge creation with the use of industrial energy efficiency networks (IEENs): A Swedish case study”
Energy Research and Social Science, Vol. 42 (2018), pp. 147-154.

This paper studies how a Swedish municipality can collaborate with the use of industrial energy efficiency networks (IEENs), with a focus on local industry and local authorities. Earlier studies from Germany and Switzerland have shown that this type of program can increase the amount of realized energy efficient measures.

The aim of this paper is to understand how the use of IEENs can bridge the gap between energy audits and the implementation of actual energy efficiency measures by exploring a municipality in Sweden that has worked with local industry in this way. The case study is investigated with the use of interviews and documents, and is compared with a German experience that involved working with a type of IEEN. The paper discusses how situated social learning can enhance our understanding of IEENs. The theoretical concept of community of practice (COP) is used to analyze the results.

In this study, it was found that IEENs should be recognized as an effective policy instrument for municipalities that are interested in supporting the local industry in work with energy efficiency.

The results of this paper show that when local industry participates in an IEEN project, in which the focus is on practice and on increased company involvement, it has a strong chance to successfully bridge the gap between energy audits and actual energy efficiency measures.

By complementing technology- and information-oriented solutions with the development of local practices, the industry can combine situated practical relevance for individual companies with best-practice knowledge from experts and from other companies experiencing similar problems. Factors such as trust, value, situated practical experience, knowledge creation, and informal meetings are important to the successful outcome of the network goal. It is interesting to note that being involved and active in the process not only helps to bridge the energy efficiency gap but also helps the SMEs to develop relevant knowledge and skills. The knowledge gained from this study can provide municipal policymakers with ideas on and insight into how they can work together with local SMEs to improve environmental work in local industry.

Article 4

Title: “Knowledge-creating platforms as a support for energy efficiency work by SMEs”

Submitted to the *Journal of Cleaner Production*

Earlier studies on both SMEs and large companies have found that despite the existence of cost-effective energy efficiency measures, investments in energy efficiency often have a low implementation rate. This paper draws on insights gained from articles 1 and 2 to examine and compare two municipal policy programs that support SMEs in Sweden. This article examined two case studies with a focus on what SMEs do with information and how knowledge is created within SMEs, and explored how the concept of explicit versus tacit knowledge relates to information and knowledge. COP theoretical practice was used to analyze how knowledge was socially constructed and how interpretations affected the information that had been supplied in the form of documents.

The results from this paper indicate that providing a platform for knowledge creation is an important factor when designing policy programs. It must also be said that technological solutions are not unimportant. In fact, the type of energy efficient measure to be implemented and its complexity level determines how energy efficiency work among SMEs should be supported.

The proposed framework will help future actors to design policy programs that support SMEs' work with energy efficiency. This paper discovered that a barrier exists to energy efficiency that has not previously been debated in research on policy programs targeting SMEs. This barrier relates to how SMEs turn supplied information into useable knowledge and/or skills. These findings are of importance to municipal policy makers who are forming policy programs.

Discussion

The aim of this thesis is to analyze how municipalities have supported SMEs in their work to improve in-house energy efficiency. The purpose is to increase the current understanding of how the methods and tools used by municipalities can influence the end results of attempts to improve energy efficiency, and how knowledge about energy efficiency is created within SMEs. In this chapter, I discuss my results, the studied companies, and the methods used.

Specific comments regarding the articles

In article 1, I examine how a municipality worked to support local SMEs in their attempts to improve their energy efficiency. It was found that the policy network in the municipality had an overly general goal that was not related to the goals held by the network members. In addition, the companies' participation was passive in nature—that is, the companies simply received information from the environmental office, and few or no company-to-company interactions occurred. The network did not become a learning network, nor did it explore the experiences that its members might possess in relation to energy efficiency. Instead, the environmental office retained all the information that was gained from the experts in the project and only disseminated this information as a report to each network member. The environmental office created an investment plan and suggested which energy efficient measures the SMEs should implement (see Figure 6). Information and generalized beliefs spread mainly via one-way communication from the environmental office to the companies. In the end, however, it was left up to the SMEs to make sense of the report and implement the suggested solutions.

Figure 6 Implementation process in article 1

It is interesting to consider how the end results might have differed if the municipality had not had such a top-down approach and if it had listened more to the needs of the involved SMEs.

What might have happened if the municipality had chosen a model that was more similar to that used in case study 2? Although this is obviously impossible to know, it is at least possible to reflect on this question in relation to what was learned from case study 2.

If the model in case study 2 had been used by the municipality in case study 1, it may well have resulted in much more engaged SMEs. The suggested energy efficient measures would have been more adapted to the need of every specific company, rather than highlighting general measurements that many SMEs would benefit from implementing. A more company-focused model could have benefited knowledge creation within the companies, which could have increased the number of energy efficient measurements that were actually implemented.

Compared with the SMEs that were studied in case 2 (and discussed in article 3), many of the SMEs in case 1 were micro and small enterprises. This fact makes it more difficult to compare the two cases. Earlier research, as well as most articles on energy efficiency, barriers, and drivers, mainly involve large and/or energy-intensive companies. Not much has been written on non-energy-intensive SMEs, and still less has been written on micro and small enterprises. It was thus difficult to compare the results of case study 1 with earlier research in order to reflect on how these micro enterprises might have reacted if they were involved in a model like the one in case study 2. The outcome may have been the same—with only a few energy efficiency measures being implemented—simply because micro enterprises have fewer personnel and less money available to invest in energy efficiency. From this perspective, it may have been an advantage that the model used in case study 1 did not demand too much from the participating companies.

Another reflection in relation to case study 1 is that the municipality began to work with 200 companies, but decided to give free energy audits to only 60 companies in phase two of the project. The reason for this reduction was not clearly spelled out; however, it is likely that there was not enough money in the project to provide free energy audits by external consultants to 200 SMEs. If 200 SMEs had participated in the project, it would have been possible to perform a quantitative study and make use of statistical analysis. This was not possible, however, so it was necessary to rely on qualitative data in the analysis, and it is therefore not certain that the sample studied here reflects the total population. This is a drawback when studying an ongoing process: It is difficult to control important parameters.

On the other hand, studying an ongoing process makes it possible to ask for actors' current reasoning rather than depending on what the actors remember about their reasoning afterward. Of the case studies in this thesis, case study 1 was ongoing, and was therefore much more difficult to follow than case study 2. Case study 2 had run for some years; thus, it was possible to obtain a more straightforward construction afterwards, when some time had passed, since the project leader had time to evaluate and reflect on the results and process in a report.

Article 2 focuses on the barriers experienced by micro and small companies—that is, on what hinders them when they attempt to implement energy efficient measures. It was found that the barriers experienced by the studied companies were related to a lack of time and/or to having other priorities; to having other priorities for capital investments; to slim organization; and to a lack of technical skill. This result has some similarities to the results of earlier barrier studies (Rohdin and Thollander, 2006; Thollander and Ottosson, 2008), which used the same questionnaire as the one used in this thesis to examine both large and energy-intensive companies, and non-energy-intensive companies. Using the same questionnaire made it possible to compare my results with theirs in order to identify deviations and similarities. With my small sample, however, it was impossible to perform a separate statistical analysis. Otherwise, it would have been interesting to use statistical analysis to discover how different barriers are dependent on each other, or to identify which barriers can be considered relevant. It would be interesting to conduct such a statistical study for micro enterprises in future research.

Article 3 presents and analyzes case study 2. From the start, the municipality in case study 2 focused on having the involved SMEs be active participants and provide input on what was important for them to discuss and include in the network. This focus led to the creation of a common goal that all SMEs could adhere to, and that was perceived as valuable and relevant for their continued work. The strength of the network structure was then utilized for creating knowledge, disseminating information, and sharing experiences between the SMEs (see Figure 7). Energy experts were made available to assist the SMEs in their practical work identifying and implementing energy efficient measures. The SMEs were taught to do basic energy audits and to look for unnecessary energy use in their own companies, in a hands-on manner.

As a result, the SMEs became able to look for energy efficient measures that were relevant and valuable to them within their company-specific setting. The end results from the SMEs' final reports in case study 2 show a high degree of realized measures. Most of the SMEs reached the agreed-upon common goal, and some even surpassed that goal.

Figure 7 Implementation process in article 1

As shown in Figures 6 and 7, the two municipal models were quite different in terms of the municipal view of how the SMEs were to be involved and in terms of focus—that is, whether the focus was on information, or on knowledge creation and learning. Articles 3 and 4 provide a rather positive picture of how the municipality in case study 2 supported the SMEs with their energy efficiency work and how the network was constructed. This positive view was influenced by the final documents that contained evaluations and results from this policy program, and by the interviews I conducted with a fewer number of SMEs than in the first case. Upon reflection, the results may not have been so positive if I had done more interviews and if I had not had access to the final reports from the beginning.

These reports might have prompted me to be more positive than I otherwise would have been when interviewing, for example, the project leader. The results might also have been different if the SMEs that I interviewed had performed very little implementation of energy efficient measures. Although some of the involved SMEs performed lower than average when compared with the other SMEs, in the end, those who granted me interviews were the SMEs who had been more successful in their implementation. On the other hand, the work by the municipality in case study 2 better aligned with the theoretical models for knowledge creation than the one in case study 1; therefore, the second municipality's process had better prerequisites to support knowledge creation in SMEs than that of the first municipality, regardless of the end results in the SMEs. In addition, the order of the case studies might have had an influence, in that I may have obtained a more positive view of case 2 than I would have done if it had been the first case I studied.

The results from article 4 indicate that providing SMEs with a platform for knowledge creation is an important factor when designing policy programs. However, it is also important to note that technological solutions are not unimportant. The type of energy efficient measure to be implemented and its complexity level also determine how a municipality should support energy efficiency work among SMEs. The results in article 4 can probably be generalized, irrespective of the size of the company, and may well be valid for both energy-intensive and non-energy-intensive companies. In my opinion, these results are also relevant to other areas of research that investigate knowledge creation and information.

One aspect that was not studied in article 4 was how decisions were made within an SME regarding what energy efficient measures would be implemented. This area requires further study, since the process by which decisions are actually made is important when studying SMEs and how they work with energy efficiency. For example, how are internal calculations performed? Is a simple pay-off method used, or is a life-cycle cost analysis used (Thollander et al., 2018)? Do SMEs perform such calculations at all when making decisions? This line of investigation is important for future research.

Comments

Finally, it must be said that in terms of dealing with energy efficiency on a national scale, this thesis has omitted an important contribution to decreased energy use, and especially to the environmental impact of energy use. This thesis only focuses on internal energy efficiency in SMEs, and does not consider other types of energy usage such as external transportation. As discussed in the introduction (see Figure 1, p. 16), national transportation occupies a considerable share of the total energy use in Sweden. This share will probably increase with increasing globalization and a continued outsourcing of manufacturing to low-cost countries. Future research into energy efficiency should therefore include this factor when trying to determine how Sweden can continue to decrease its energy use.

Other topics for discussion include why so few studies use advanced statistical methods to examine energy efficiency and, specifically, to examine barriers to energy efficiency; and what importance strategy may have in implementing energy efficient measures. It is true that some simple statistical studies have been done, in which percentage is used to illustrate which barriers and drivers impede the implementation of energy efficient measures, or to explain the existence of an energy gap. Very few of these studies use advanced statistical analysis, such as factor analysis or regression analysis, even though computer software is available and there appears to be sufficient data collected for such an analysis. I believe that by combining quantitative studies with qualitative studies in future research, new conclusions might be drawn and new questions might be raised.

Conclusions

In order to fulfill the aim of the thesis, I have asked and answered three research questions. First, I examined how municipalities work in different ways to support SMEs in their energy efficiency work. Second, I studied how the barriers experienced by SMEs prevent them from implementing energy efficient measures, and how these barriers can be overcome with the help of municipal policy programs. Third, I compared different municipal policy programs and considered possible reasons why they ended up with different end results. Here, my focus was on knowledge creation and information, and how they interact with each other.

In this concluding chapter, I discuss the results of the articles and summarize my conclusions in relation to the aim and the research questions. I end with some implications for future policy programs on energy efficiency in SMEs, and with suggestions for further research.

Two cases studies on municipalities supporting SMEs in improving energy efficiency

RQ 1: How did the two studied municipalities support SMEs in their energy efficiency efforts?

The first research question asks how municipalities have supported SMEs in their work to improve their energy efficiency. Although the two municipalities initiated and ran their projects in different ways, both used a network structure as the project form.

In the first case study (article 1), the SMEs involved in the project were provided with free energy audits and energy investment plans. The project was instigated because the municipality considered that local SMEs did not do enough to reduce their energy use. The municipality decided that it could assist in lowering the thresholds to energy efficiency, which were being experienced by SMEs in the form of different barriers, by means of an information-oriented project. The idea was that providing SMEs with enough information would lower the thresholds and cause the SMEs to implement more energy efficient measures. In this case, the municipality rigidly steered the project based on its own goals, which were guided by the ambitious environmental policy that had been decided on at the political level. The SMEs involved in the project had little voice regarding what goals should be fulfilled and how this should be done.

This top-down type of governance was problematic in some areas; in the end, few of the energy efficient measures were implemented, and the municipality's goals remained unfulfilled. One of the problems with this project was that the SMEs became passive recipients of information that, in many ways, was not relevant or valuable to them. Another problem with the municipality's steering was that the network structure was never utilized, and the SMEs never came together as a network.

In the second case study (article 3), the municipality chose a different way to support SMEs with their energy efficiency efforts. From the start, this municipality's focus was on having the involved SMEs become active participants in the project, so that the SMEs would provide input regarding their priorities, and so that the network would come up with a goal that all the participating SMEs could adhere to. The strength of the network structure was utilized to disseminate information, questions, and shared experiences between the SMEs.

The answers to the first research question indicate that the two studied cases show two different ways in which municipalities supported SMEs in their efforts to improve their energy efficiency. It was also discovered that the end results of the two projects differed considerably.

RQ 2: How do SMEs view barriers to energy efficiency, and what kind of municipal support is important to improve energy efficiency in SMEs?

The second research question was influenced by recent literature discussing the lack of implemented energy efficient measures in enterprises—that is, the gap between potential and realized energy efficient measures. I thought it would be interesting to see how SMEs regard barriers to energy efficiency, and to discover whether the studied SMEs encountered general barriers that they considered to be more prominent than others in their efforts to improve energy efficiency. This interest prompted the study in article 2, where it was found that the most prominent barriers experienced by the studied SMEs were as follows: (1) bounded rationality (i.e., a lack of time and/or other priorities); (2) split incentives (i.e., having other priorities for capital investments); and (3) imperfect information (i.e., slim organization and a lack of technical skill). Another result discussed in article 2 was that the main thing the SMEs gained from the municipal project in case study 1 was information in the form of a report; however, they were not provided with tools, skills, or knowledge to interpret the report or make it relevant within their local context.

These results were important for the thesis as a whole, as they caused me to reflect on why the results in case study 1 and 2 differed so much, and thereby contributed to the formulation of research question 3.

RQ 3: Do different municipal policy programs exhibit different end results in terms of energy efficiency improvement in SMEs, and if so, how?

For the third and last research question, it was interesting to compare the two cases, see what differences were apparent, and attempt to explain why the end results differed (article 4). Upon comparison, it was obvious that the end results of the two case studies differed not only in the number of measures that had been implemented, but also in the type of measures that were implemented. Article 4 focuses on how the SMEs received information from energy audits and created knowledge that was valuable and relevant for them within their own enterprise. A starting point for this article was the concept that knowledge is socially constructed, and that received information would therefore usually be interpreted differently by different SMEs. This occurs because knowledge is dynamic, relational, and based on human action; it depends upon the situation and the people involved rather than relying on some objective truth (which does not exist in such a case). In other words, individuals tend to interpret things based on their own previous experience, education, knowledge, and cultural background.

Therefore, if SMEs are provided with a document detailing the results of an energy audit or investment plan—which may be performed by an energy expert with specific skills and experience—the document will not be translated in an unaffected manner by the SMEs; rather, the SMEs will interpret the document based on their own perceptions and needs. Rather than being passive recipients of information, SMEs need to be active and participate in a hands-on manner from the start of an energy efficiency project; thus, the person involved in the energy audit will also be the one who is later involved in the process of implementing energy efficient measures. A project that is run in this way allows knowledge creation and information to interact in a constructive way, moving the work forward. These are the main conclusions from article 4, as well as being the answers to research question 3.

Concluding reflections for future policy programs on energy efficiency for SMEs

It is important to acknowledge that there is no single way to support SMEs in improving their energy efficiency. Rather, the group's common goal, the type of technology implementation, and the level of knowledge and skill among the SMEs should determine how a municipality can best support SMEs in their implementation of energy efficiency measures.

One of the main results of this thesis is the realization that knowledge and information are not equivalent for SMEs, and that this fact should be taken into account when creating a policy program to support SMEs in their energy efficiency efforts. Knowledge is socially constructed and is dependent on culture and background; when SMEs are provided with information from energy audits, they must negotiate this information within the context of their own company to determine what is relevant and valuable to them. Therefore, when creating policy programs for SMEs, it is necessary to move away from the perspective of lowering information barriers by providing abstract information, and move toward a more practice-oriented approach in which the human dimension is more pronounced. It is also important to determine the level of knowledge and skill among the participating SMEs at the start of a project. A second significant result of this thesis is the finding that the kind of technological or processual solution identified by the energy audits affects the design of a policy program.

Therefore, in future, municipalities should consider the following factors when designing policy programs to support SMEs in their work with energy efficiency:

- No policy program works for all types of SMEs, as enterprises are heterogeneous in nature in terms of their needs, skills, knowledge, and attitude toward energy efficiency. Municipalities must be perceptive of the needs of the participating SMEs rather than attempting to steer them from a top-down position.

- Information is not automatically translated into useable knowledge by SMEs in a linear fashion; that is, an energy audit by an external energy expert followed by an investment plan does not necessarily result in the implementation of energy efficient measures. Instead, a platform must be created that enables SMEs to negotiate the information they receive, and to create useable knowledge from it.
- It is important to consider the type of technological solution and complexity level when designing policy programs for energy efficiency.

Suggestions for future research

As demonstrated by this thesis, the way in which a municipality supports SMEs in implementing energy efficient measures can have a large impact on the end results in terms of the number and type of energy efficient measures that are actually implemented. This finding needs to be complemented by studies on how SMEs actually make the decisions that lead to the implementation of energy efficient measures. Studies on risk and bounded rationality show that actors do not make decisions in an economically rational way; other factors influence choice (Kahneman, 2011). Therefore, in order to improve existing knowledge on the implementation of energy efficient measures by SMEs, more research should be dedicated to this topic.

This thesis contributes to energy efficiency research; however, if SMEs are to increase their implementation rate of energy efficient measures, it is necessary to know more about how to achieve this end result. We must probe deeper, not only by examining the subject of decision-making, but also by combining quantitative and qualitative studies. In doing so, new insights can be gained that will further the critical topic of energy efficiency research.

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